Fall Creek Watershed Assessment and Total Maximum Daily Load

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Acronyms and Symbols

§303(d) Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired waterbodies required by this section

AWS agricultural water supply

BLM United States Bureau of Land Management

BURP Beneficial Use Reconnaissance Program

C Celsius

CFR Code of Federal Regulations (refers to citations in the federal administrative rules)

CNF Caribou National Forest (USFS)

cfs cubic feet per second

cm centimeters

CWA Clean Water Act

DEQ Idaho Department of Environmental Quality

DWS domestic water supply

EPA United States Environmental Protection Agency

F Fahrenheit

FWS U.S. Fish and Wildlife Service

GIS Geographical Information Systems

HUC Hydrologic Unit Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDWR Idaho Department of Water Resources

LA load allocation

LC load capacity

µg/g micrograms per gram, equivalent to parts per million

m meter

m^3 cubic meter

mi mile

mi^2 square miles

MBI macroinvertebrate index

mm millimeter

MOS margin of safety

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

PCR primary contact recreation

ppm part(s) per million

SCR secondary contact recreation

SCS Soil Conservation Service

SS salmonid spawning

TMDL total maximum daily load

TNF Targhee National Forest (USFS)

US United States

USC United States Code

USFS United States Forest Service

USGS United States Geological Survey

WLA wasteload allocation

Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize waterbodies that are water quality limited (i.e., waterbodies that do not meet water quality standards). States and tribes must periodically publish a priority list of impaired waters, currently every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. This document addresses the waterbodies in the Fall Creek watershed that have been placed on what is known as the "303(d) list".

This watershed assessment and TMDL analysis has been developed to comply with Idaho's TMDL schedule. This assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Fall Creek watershed in southeast Idaho. The first part of this document, the watershed assessment, is an important first step in leading to the TMDL. The starting point for this assessment was Idaho's current 303(d) list of water quality limited waterbodies. Two segments of the Fall Creek watershed are included on this list. The watershed assessment portion of this document examines the current status of 303(d) listed waters, and defines the extent of impairment and causes of water quality limitation throughout the watershed. The loading analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Watershed at a Glance

The Fall Creek watershed is in the Caribou mountains of the Caribou-Targhee National Forest in eastern Idaho. Figure 1 shows the location of Fall Creek watershed within the Palisades subbasin. This document addresses the segments of Fall Creek and Camp Creek in the Palisades Subbasin that have been placed on the 303(d) list for impaired water quality, shown in Figure 1 by bolder lines for the listed stream reaches. The Fall Creek watershed is designated by the 5^{th}-field Hydrologic Unit Code (HUC) 1704010411. The remainder of 5^{th}-field HUC watersheds in Palisades subbasin have been assessed and pollutant loads allocated in the Palisades Subbasin Assessment and Total Maximum Daily Load Allocations (Zaroban and Sharp 2001).

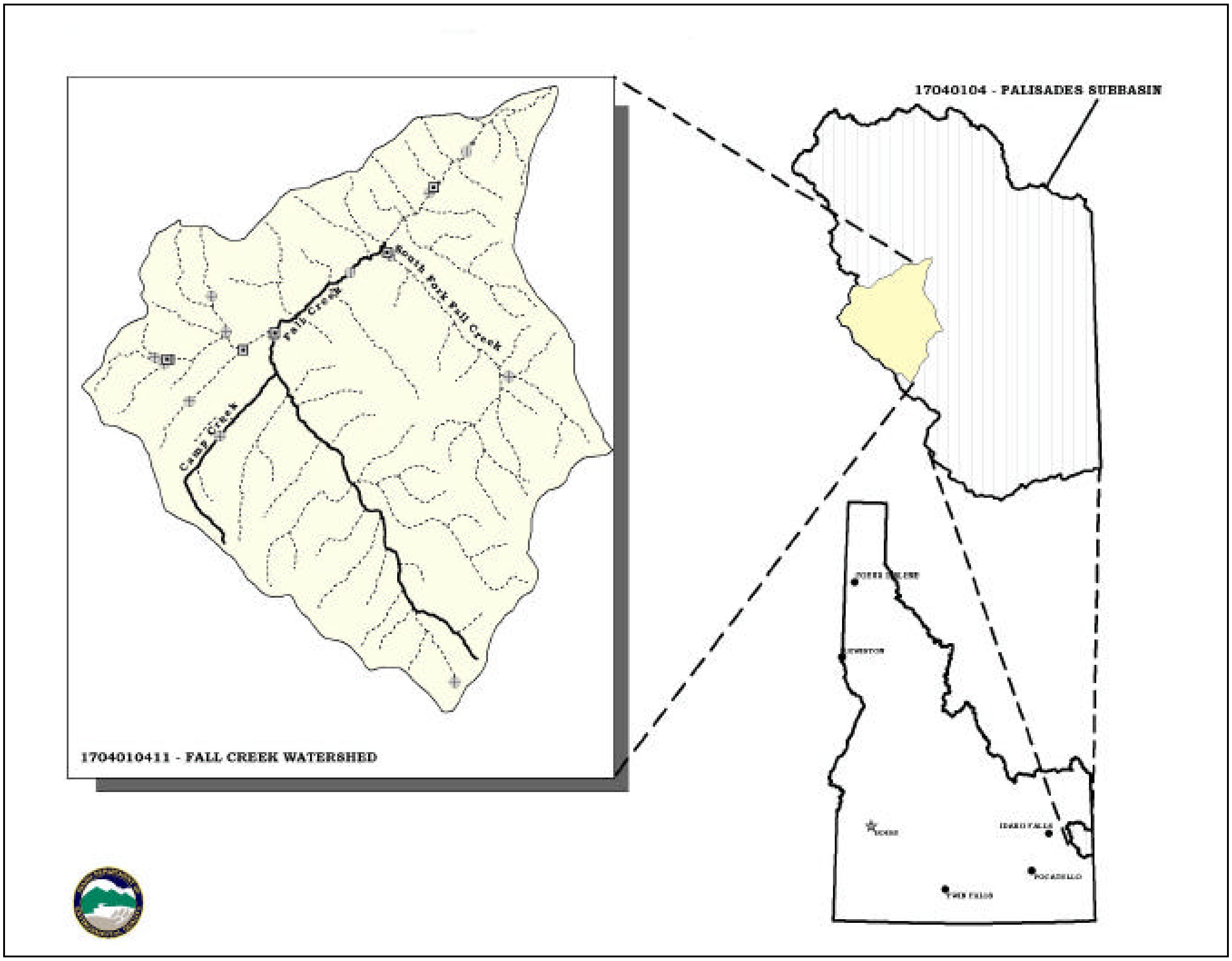


Figure by Sean Coyle

Figure 1 Fall Creek Watershed Location in Palisades Subbasin

Fall Creek at a Glance

Geomorphic characteristics

- Second order stream
- Rosgen C channel type

Management in riparian area

- Grazing
- Recreational land use

Listing history

- Fall Creek was placed on the State of Idaho 1998 303(d) list due to macroinvertebrate biotic index scores showing one site with impaired water quality and one site that needs verification. Fall Creek is listed from its headwaters to the South Fork Fall Creek confluence, a total of 12.18 stream miles.

Pollutant of Concern

- Sediment and Temperature

Water Quality Assessments

- Beneficial Use Reconaissance Program
    - Fall Creek 1996SIDFY014 Stream Macroinvertebrate Index (SMI) = minimum threshold = not full support, Stream Habitat Index (SHI) = 2; 60% surface fine sediment, 18.9 width/depth ratio.
    - Fall Creek 1996SIDFY017 SMI = minimum threshold = not full support, SHI = 1 ; 53% surface fine sediment, 9.7 width/depth ratio.
    - Fall Creek 1996SIDFY032 SMI = 3 , SHI = 1 , Ave. Score = 2 = full support; 36% surface fine sediment, 10.9 width/depth ratio.
    - Salmonid spawning
        - 2 age classes, including juveniles, yellowstone cutthroat trout
        - 3 age classes, including juveniles, brook trout
- Idaho DEQ 2002
    - McNeil sediment core sampling = 39% subsurface fine sediment
    - Streambank erosion inventory
        - Upper Fall Creek erosion rate = 65 tons/mile/year
        - Upper Fall Creek streambanks = 64% stable
- USFS 2001, 2002, 2003
    - Continuously recorded stream temperatures = exceed spring salmonid spawning criteria

Sediment Total Maximum Daily Load (TMDL)

A TMDL is the sum of wasteload allocations for point sources and load allocations for nonpoint sources, and including a margin of safety, to-wit:

TMDL = WLA + LA + MOS

WLA

WLA = 0 (No point sources)

LA Load allocation = 11 tons/mile/year sediment load.
Existing erosion rate = 65 tons/mile/year.
Proposed reduction = -54 tons/mile/year or 83% erosion rate reduction.
Therefore, to achieve the goals of 28% subsurface fine sediment and 80% streambank stability, the sediment load should be reduced by 83%.

MOS

A margin of safety is provided implicity through the analytical assumptions made in setting the 80% streambank stability and 28% subsurface fine sediment goals. An additional MOS is provided by the assumption that the entire listed reach is eroding at the same rate as the inventoried section.

Temperature Total Maximum Daily Load (TMDL)

A TMDL is the sum of wasteload allocations for point sources and load allocations for nonpoint sources, and including a margin of safety, to-wit:

TMDL = WLA + LA + MOS

WLA

WLA = 0 (No point sources)

LA Load allocation = 2.4 kWh/m^2/day or 62% effective shade.
Existing load = 4.6 kWh/m^2/day or 30% effective shade.
Proposed reduction = 47% reduction in solar load and stream temperature.
Therefore, to achieve the goals of salmonid spawning criteria, the solar load and stream temperatures should be reduced by 47%. Accomplishing these goals can be achieved by increasing effective shade by 32% through riparian vegetation development.

MOS

A margin of safety is provided implicity through the analytical assumptions made by using the highest recorded temperature in the data set to compare to standards as opposed to an average high value.

Camp Creek at a Glance

Geomorphic characteristics

- First order stream
- Rosgen B channel type

Management in riparian area

- Grazing
- Roads through channel

Listing history

- Camp Creek was placed on the State of Idaho 1998 303(d) list due to a macroinvertebrate biotic index score showing impaired water quality. The entire length of Camp Creek from its headwaters to the confluence with Fall Creek is listed, a total of 4.57 stream miles.

Pollutant of Concern

- Sediment

Water Quality Assessments

- Beneficial Use Reconaissance Program
  - Camp Creek 1996SIDFY030 SMI = minimum threshold = not full support, SHI = 1; 61% surface fine sediment, 12.5 width/depth ratio.

- Idaho DEQ 2002
  - Salmonid spawning
    - one age class rainbow/cutthroat hybrid
  - Streambank erosion inventory = 189 tons/mile/year with 26% stable streambanks.

Sediment Total Maximum Daily Load (TMDL)

A TMDL is the sum of wasteload allocations for point sources and load allocations for nonpoint sources, and including a margin of safety, to-wit:

TMDL = WLA + LA + MOS

WLA

WLA = 0 (No point sources)

LA Load allocation = 10 tons/mile/year sediment load.
Existing erosion rate = 189 tons/mile/year.
Proposed reduction = -179 tons/mile/year or 95% erosion rate reduction.
Therefore, to achieve the goals of 28% subsurface fine sediment and 80% streambank stability, the sediment load should be reduced by 95%.

MOS

A margin of safety is provided implicity through the analytical assumptions made in setting the 80% streambank stability and 28% subsurface fine sediment goals. An additional MOS is provided by the assumption that the entire listed reach is eroding at the same rate as the inventoried section.

Key Findings

The designated beneficial uses for cold water aquatic life are not being met in Camp Creek and Fall Creek. Excess sediment due to legacy management practices in the watershed is adversely impacting cold water aquatic life. Goals are set for Camp Creek and Fall Creek to achieve 80% streambank stability and 28% subsurface fine sediment in order to fully support the beneficial uses for cold water aquatic life. Additionally, stream temperature reductions are necessary to achieve salmonid spawning criteria in Fall Creek. The timeframe for achieving these goals will be determined by a phased approach for implementation of riparian improvements based upon progress shown by monitoring. Table A shows the stream segments and pollutants for which TMDLs are developed.

Table A. Streams and pollutants for which TMDLs are developed.

Source	Boundaries and AUs	Pollutant	Existing Load	Allocation	Reduction (%)
Camp Creek	Headwaters to confluence (ID17040104SK006_02)	Sediment	189 tons/mi/yr	10 tons/mi/yr	95
Fall Creek	East Fork to mouth (ID17040104SK006_04)	Temperature	4.6 kWh/m^2/day	2.4 kWh/m^2/day	47
Fall Creek	East Fork to mouth (ID17040104SK006_04)	Sediment	65 tons/mi/yr	11 tons/mi/yr	83

A summary of the assessment outcomes is given in Table B. The boundaries of the listed portion of Fall Creek should be changed as shown.

Table B. Summary of assessment outcomes.

Waterbody segment	Assessment Units (AUs)	Pollutant	Listed Segment	Changes to the 303(d) list
Camp Creek	ID17040104SK006_02	Sediment	Headwaters to confluence	None
Fall Creek	ID17040104SK006_03 & _04	Sediment Temperature	From headwaters to confluence with South Fork Fall Creek	From East Fork to mouth (ID17040104SK006_04 only)

1. Watershed Assessment-Watershed Characterization

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize waterbodies that are water quality limited (i.e., waterbodies that do not meet water quality standards). States and tribes must periodically publish a priority list of impaired waters, currently every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses the segments of Fall Creek and Camp Creek in the Palisades Subbasin that have been placed on the 303(d) list for impaired water quality. The entire length of Camp Creek and Fall Creek from its headwaters to South Fork Fall Creek are on the 303(d) list for water quality impaired due to unknown pollutants. The Fall Creek watershed is designated by the 5th-field Hydrologic Unit Code (HUC) 1704010411. The remainder of 5th-field HUC watersheds in Palisades subbasin have been assessed and pollutant loads allocated in the Palisades Subbasin Assessment and Total Maximum Daily Load Allocations (Zaroban and Sharp 2001). In the Palisades subbasin assessment, the listed portions of Fall Creek and Camp Creek were deferred to collect more information. These listed streams were additions to the original court settlement of Idaho's TMDL progress. Streams added after the settlement may be deferred until the end of the TMDL schedule.

The overall purpose of this watershed assessment and TMDL is to characterize and document pollutant loads within the Fall Creek watershed. The first portion of this document, the watershed assessment, is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and a summary of past and present pollution control efforts (Chapters 1 – 4). This information will then be used to develop a TMDL for each pollutant of concern for the Fall Creek watershed (Chapter 5).

1.1 Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Pollution Control Federation 1987). The act and the programs it has generated have changed over the years as experience and perceptions of water quality have changed. The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to ensure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality to more than just chemistry.

Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Department of Environmental Quality (DEQ) implements the CWA in Idaho, while the EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Section 303 of the CWA requires DEQ to adopt, with EPA approval, water quality standards and to review those standards every three years. Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish TMDLs for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the waterbodies to meet their designated uses. These requirements result in the 303(d) list detailing impaired waters. This list describes waterbodies not meeting water quality standards. Waters identified on this list require further analysis. A watershed assessment and TMDL provide a summary of the water quality status and allowable TMDL for waterbodies on the 303(d) list. The Fall Creek watershed assessment and total maximum daily load provides this summary for the currently listed waters in the Fall Creek watershed of the Palisades subbasin.

The watershed assessment section of this report (Chapters 1 – 4) includes an evaluation and summary of the current water quality status, pollutant sources, and control actions in the Fall Creek drainage to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a waterbody and still allow that waterbody to meet water quality standards (Water quality planning and management, 40 CFR 130). Consequently, a TMDL is waterbody- and pollutant-specific. The TMDL also includes individual pollutant allocations among various sources discharging the pollutant. TMDLs are not required for waterbodies impaired by pollution, but not specific pollutants. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several waterbodies and/or pollutants within a given watershed.

Idaho's Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a waterbody by designating the use or uses for the water, setting criteria believed necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards and include:

- Aquatic life support – cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation – primary (swimming), secondary (boating)
- Water supply – domestic, agricultural, industrial
- Wildlife habitats, aesthetics

The Idaho legislature designates uses for waterbodies. Industrial water supply, wildlife habitat, and aesthetics are designated beneficial uses for all water bodies in the state. If a waterbody is unclassified, then cold water and primary contact recreation are used as default uses when waterbodies are assessed.

A watershed assessment entails analyzing and integrating multiple types of data, such as biological, physical/chemical, watershed, and landscape to address several objectives:

- Determine the degree of designated beneficial use support of the waterbody
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the waterbody, particularly the identity and location of pollutant sources.
- When waterbodies are not attaining water quality standards, determine the causes and extent of the impairment.

1.2 Physical and Biological Characteristics

Watershed characteristics relevant to pollutants impairing beneficial uses are assessed by describing physical and biological characteristics of the watershed, including a description of the climate, hydrology, and unique characteristics of the individual streams in the watershed. To evaluate the Fall Creek watershed for sensitivity to activities that may impair beneficial uses of the waterbodies, the geology, soils, vegetation, and assemblages of aquatic life are identified and described.

The Fall Creek watershed is in the Caribou mountains of the Caribou-Targhee National Forest in eastern Idaho. Figure 1 shows the location of Fall Creek watershed within the Palisades subbasin. This watershed is a mix of forested areas and rangeland, predominantly under federal ownership and managed by the US Forest Service (USFS). The area is very rural with good wildlife habitat high in the hills where designated forest routes and other motorized travel cannot interfere. Humans use the Fall Creek watershed mainly for recreational activities and for rangeland to graze sheep and cattle.

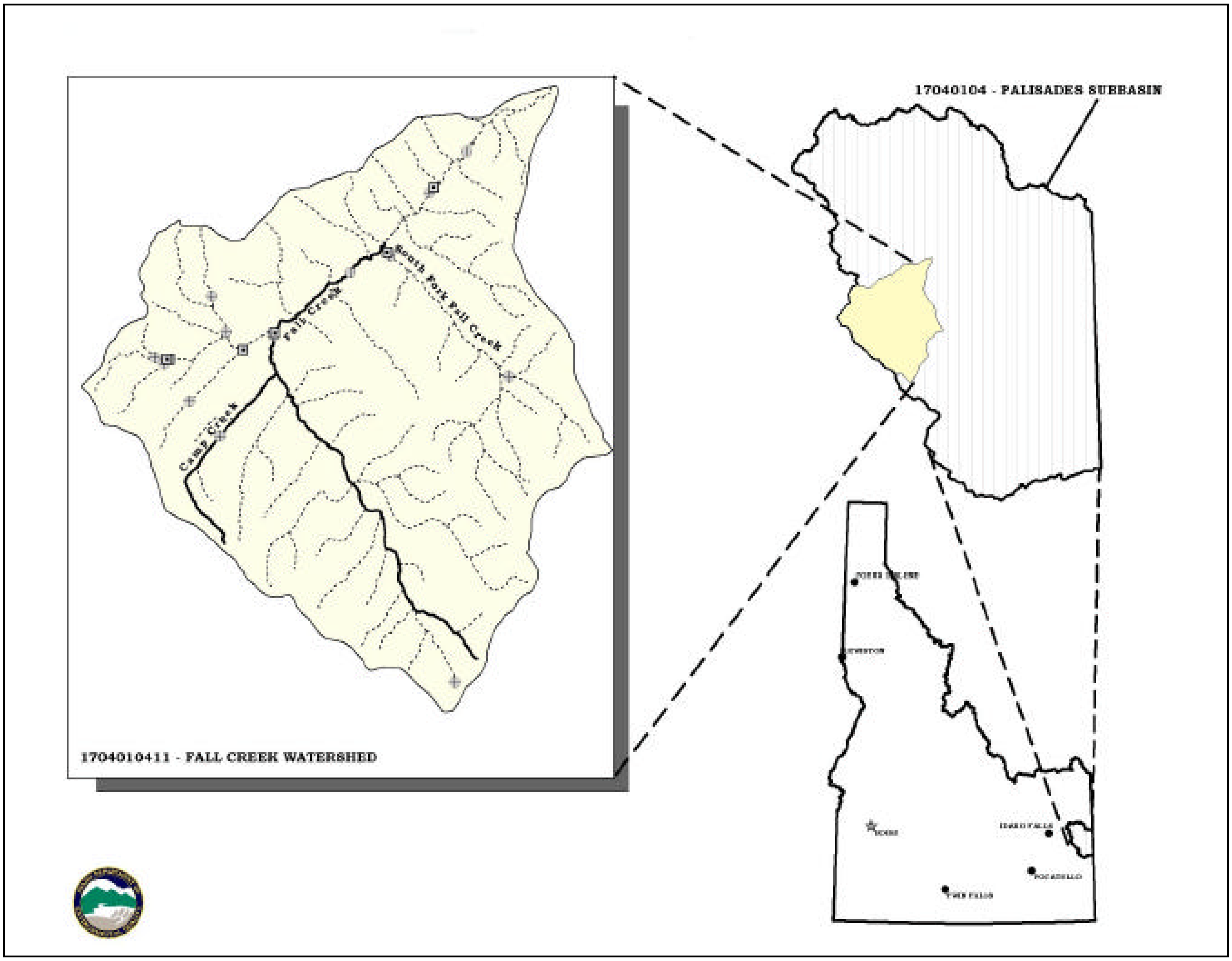


Figure by Sean Coyle

Figure 1 Fall Creek Watershed Location in Palisades Subbasin

Climate Description

The climate of the Fall Creek watershed is semiarid with cool, moist winters and warm, dry summers. Air masses from the Pacific Ocean, Gulf of Mexico, and central Canada affect the region, tempered by the strong topographical relief of the Rocky Mountains. In winter, prevailing western winds deposit most of the annual moisture in the form of snow from late October through early May. The mountains partially shield the region from extremely cold, dry arctic winds. Winters are cold, but not generally severe (Rupert 1994). During summer months, western winds are weaker and partially blocked from bringing precipitation into lower elevations of the watershed, leaving rainfall, cloud cover and humidity at a minimum. Continental conditions predominate during the summer, with sporadic thunderstorms from subtropical oceanic airflow (Abramovich et al. 1998).

Monthly normal temperatures and precipitation for the two Western Regional Climate Center weather stations nearest to the Fall Creek drainage are presented in Table 1.

Table 1. Summary of monthly data from 1971 through 2000 for Palisades and Swan Valley weather stations.

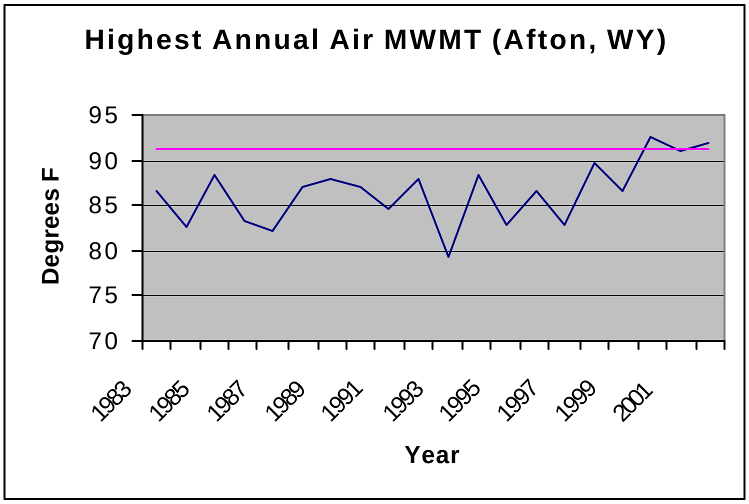
Period	Palisades			Swan Valley		
	Temperature °F		Precipitation	Temperature °F		Precipitation
	Mean Maximum	Mean Minimum	Mean Total (in.)	Mean Maximum	Mean Minimum	Mean Total (in.)
Jan.	31.0	15.3	2.03	29.6	11.7	1.54
Feb.	36.6	16.7	1.59	35.4	14.8	0.97
March	45.3	23.4	1.63	44.1	22.8	1.38
April	56.1	30.7	1.67	54.9	28.9	1.62
May	65.8	38.6	2.63	64.4	36.0	2.75
June	75.9	46.3	1.68	74.7	42.0	1.48
July	84.7	52.5	1.28	83.7	46.6	1.39
August	83.8	51.0	1.52	82.9	45.7	1.34
Sept.	74.8	42.7	1.44	73.1	37.5	1.39
Oct.	61.5	34.6	1.45	59.7	28.8	1.37
Nov.	43.0	25.9	1.78	41.2	21.1	1.53
Dec.	32.1	17.6	1.71	30.6	12.4	1.30
Annual	57.6	32.9	20.41	56.2	29.0	18.06

Monthly mean maximum temperatures climb to the low 80s (°F) on average during summer months with the highest maximum temperatures occurring in July and August, while mean minimum temperatures can drop as low as 11 °F in the winter (See Table 1). The annual average maximum temperature is 56.9 °F and the annual average minimum temperature is 31 °F for the region. Total mean annual precipitation ranges from 18 to 20 inches for the region. Half of the annual precipitation in the form of rain falls in April through September, which is the typical growing season for most regional crops. The greatest average precipitation occurs in May. (Western Regional Climate Center 2002).

The ninetieeth (90^{th}) percentile of the highest maximum weekly maximum air temperatures (MWMT) was calculated from the Agrimet data set of daily maximum air temperatures for Afton, Wyoming. The highest MWMT for each year from 1983 to 2002 are shown in Figure 2. The 90^{th} percentile of these highest MWMTs was 91.2°F (32.9°C), which is shown on the figure as a straight line. Note how the last several years of the data set show highest MWMT exceeding the 90^{th} percentile.

For stream temperature recordings, all days exceeding the 90th percentile (or 91.2°F) are excluded from the analysis of water temperature criteria violations as per IDAPA 58.01.02.080.04. However, no air temperatures exceeded this level during the spring salmonid spawning period (April 1 to July 1) used in the subsequent TMDL analysis.

Figure 2. Highest maximum weekly maximum air temperatures (MWMT) for each year from 1983 to 2002 at the Afton, Wyoming Agrimet weather station. Straight line at 91.2°F is the 90th percentile of these MWMT air temperatures.



Hydrology

The primary stream in this drainage is Fall Creek, which gets its name from a 60-foot waterfall that cascades down a travertine deposit at Fall Creek's confluence with the South Fork Snake River. Fall Creek flows into the South Fork Snake River in an area where the river splits into several channels around midstream islands. According to Idaho Department of Water Resources (IDWR) data, the watershed drains 49,748.5 acres (77.7 square miles) with a total of 133.3 stream miles (IDWR 1994-1997).

The Fall Creek watershed exhibits a strongly parallel drainage pattern, as shown in Figure 3. First order streams at the top of the drainage, such as June, Monument, Camp, Haskin, Trap, and Beaver Creeks, flow in a straight northeast direction, as does the lower part of Fall Creek. Other streams flow perpendicularly into Fall Creek, including Porcupine Creek, Horse Creek, and South Fork Fall Creek. The parallel drainage pattern derives from the grid-like underlying Basin and Range block faulting (Maley 1987).

Figure by Sean Coyle

Figure 3 Fall Creek Hydrography

Runoff patterns in the Fall Creek drainage are dominated by snowmelt, with flows generally highest during spring runoff, tapering off during the summer, and lowest during fall and winter. Occasional thunderstorms will sometimes augment streamflow with a quick upsurge during the summer months (Drewes 1991).

Even though the land area drained by South Fork Fall Creek totals less than 20% of the total Fall Creek watershed, South Fork Fall Creek contributes over 50% of the stream discharge to the Fall Creek watershed (IDWR 1994-1996). South Fork Fall Creek has a west-facing aspect, which normally would be drier due to heavier evapotranspiration on the south- and west-facing aspects. However, the highest elevation in the watershed is in the headwaters of South Fork Fall Creek. Higher elevations will hold snowbanks later into the year and contribute more water for spring runoff, according to USFS observations (USFS Caribou-Targhee National Forest 2002). An additional reason for the relatively large stream discharge for this small land area is that the outcrop geology of the ridges above South Fork

Fall Creek are from the Wells, Phosphoria, and Dinwoody Formations (Jobin and Schroeder 1964). The highest level, the Dinwoody Formation, is a moderately permeable aquifer with the Phosphoria Formation beneath it, creating a very impermeable layer. Beneath the Phosphoria, the Wells Formation has moderate to very high permeability (Cannon 1979).

The groundwater in the Fall Creek watershed is not an over-utilized resource. There is only one private well in the Fall Creek watershed (M. Philbin pers. comm.).

Although there are no current realtime gages measuring water levels in the Fall Creek drainage, one U.S. Geological Survey (USGS) gage measured streamflow on Fall Creek during 1917, 1918, 1934, 1935, and 1936. Table 2 shows the available streamflow statistics during the measurement period. Available data from April through October indicate 75% of the streamflow occurring in April, May and June (USGS 2002). These data support the conclusion that snowmelt and spring runoff contribute the most significant portion of surface water in the Fall Creek drainage.

Table 2. Historical monthly streamflow statistics for Fall Creek.

Year	Monthly mean streamflow (ft^3/second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1917	?	?	?	?	?	?	70.8	?	?	?	?	?
1918	?	?	?	?	?	88.7	?	?	?	?	?	?
1934	?	?	?	?	13.7	10.8	8.74	?	?	?	?	?
1935	?	?	?	42.8	97.2	54.6	18.0	10.2	10.7	12.6	?	?
1936	?	?	?	90.6	186	68.0	28.2	20.9	14.5	15.0	?	?
Mean of monthly streamflows	?	?	?	66.7	99.0	55.5	31.4	15.5	12.6	13.8	?	?

Surface Water data for USA: Monthly Streamflow Statistics retrieved on 08/28/2002 from http:// waterdata.usgs.gov/nwis/monthly

More recent flow data was acquired during beneficial use reconnaissance by DEQ. Table 3 gives the instantaneous flow measurements recorded by Beneficial Use Reconnaissance Program (BURP) crews from the DEQ Idaho Falls Regional Office. According to BURP guidance, streams are at or near base flow (i.e., summer low flow) conditions when BURP data is collected. The summer 2001 BURP streams were sampled at near record low flow. Since they are instantaneous flow measurements, the data do not show long term trends. However, it may be observed that Monument, June, Trail, Gibson, and Camp Creeks in the upper watershed contribute little flow volume, while South Fork Fall Creek contributes the greatest volume of water to Fall Creek (DEQ 1993, 1996, 2001). Furthermore, USFS crews observed in 1999 that South Fork Fall Creek contributes 60% of the flow to Fall Creek (USFS Caribou-Targhee National Forest 2002).

Table 3. Instantaneous flow measurements in the Fall Creek watershed.

Stream (BURP site identification)	Location	Date Recorded	Flow (cubic feet/second)
Fall Creek (1993SIDFA016)	43° 23' 13.68" N -111° 27' 52.70" W	7/21/1993	17.98
Fall Creek (1993SIDFA017)	43° 25' 19.11" N -111° 24' 55.04" W	7/21/1993	31.95
Fall Creek (1996SIDFY014)	43° 16' 00.35" N -111° 25' 40.89" W	6/5/1996	0.1
Fall Creek (1996SIDFY017)	43° 22' 10.49" N -111° 24' 52.83" W	6/6/1996	51.0
South Fork Fall Creek (1996SIDFY018)	43° 23' 20.58" N -111° 26' 42.15" W	6/10/1996	23.3
South Fork Fall Creek (1996SIDFY019)	43° 21' 43.90" N -111° 24' 44.92" W	6/10/1996	25.5
Gibson Creek (1996SIDFY020)	43° 22' 45.86" N -111° 31' 19.44" W	6/10/1996	1.7
Monument Creek (1996SIDFY021)	43° 21' 06.18" N -111° 31' 54.02" W	6/11/1996	1.0
June Creek (1996SIDFY022)	43° 21' 46.32" N -111° 32' 27.27" W	6/11/1996	Beaver Complex
Trail Creek (1996SIDFY023)	43° 21' 46.05" N -111° 32' 41.09" W	9/11/1996	Beaver Complex
Gibson Creek (1996SIDFY024)	43° 22' 16.40" N -111° 13' 04.69" W	6/11/1996	4.1
Camp Creek (1996SIDFY030)	43° 20' 25.42" N -111° 31' 13.51" W	6/19/1996	2.9 Note: close to base flow--maybe a little above
Fall Creek (1996SIDFY032)	43° 24' 53.86" N -111° 25' 32.64" W	6/20/1996	55.7 Note: water still above base flow
Fall Creek (2001SIDFA002)	43° 22' 11.99" N -111° 29' 47.36" W	7/2/2001	0.28
South Fork Fall Creek (2001SIDFA003)	43° 23' 34.32" N -111° 26' 57.19" W	7/3/2001	6.06
Fall Creek (2001SIDFA005)	43° 24' 42.61" N -111° 25' 46.06" W	7/5/2001	4.12
June Creek (2001SIDFA010)	43° 21' 48.06" N -111° 32' 23.96" W	7/2/2001	Dry
Trail Creek (2001SIDFA011)	43° 21' 48.16" N -111° 32' 27.31" W	7/3/2001	Dry
Monument Creek (2001SIDFA012)	43° 21' 55.11" N -111° 30' 34.60" W	7/3/2001	Dry

Beneficial Use Reconnaissance Program (BURP) data collected by Department of Environmental Quality Idaho Falls Regional Office during 1993, 1996, and 2001. Map of BURP locations and stream discharge given in Appendix B.

Watershed Characteristics

Geology and Soils

The Fall Creek watershed lies within the Caribou Range. The range and underlying geology display a distinctive topographic trend along a northwest to southeast axis. An overthrust belt pushed from the southwest through layers of sedimentary bedrock to form the Caribou Range (Alt and Hyndman 1989). The older sedimentary bedrock is a hard Mesozoic layer composed mostly of limestone, but also exhibits layers of conglomerate, sandstone, siltstone, and shale. The overthrust belt contorted and tightly folded the sedimentary layers to such an extent that in some places the oldest layer is topmost. Later, the Caribou Range overthrust structure was broken at perpendicular lines by Basin and Range Block faulting (Maley 1987). This rectilinear structure is the cause of the parallel drainage patterns described previously and depicted in Figure 3. Pliocene rhyolitic flows overlay some of the sedimentary layers of the Caribou Range, and basalt flows overlap the base of the range (Alt and Hyndman 1989).

Unique mineralogy is created in the Fall Creek watershed by the hydrothermal seeps common in Fall Creek and Camp Creek. Travertine is formed by precipitates of carbonate and silica when hydrothermal waters evaporate. This mineral is relatively hard and resistant to erosion. The waterfalls at the mouth of Fall Creek flow over a 60-foot tall travertine deposit. A travertine rock mine is located in Echo Canyon in the lower Fall Creek drainage on a 60-acre parcel (USFS Caribou-Targhee National Forest 2002). Mineral springs are tributary to the lower reaches of Fall Creek. The hydrothermal seeps and springs may contribute to increased conductivity in the surface water (USFS TNF 1999, 2000).

The elevation ranges from 5280 feet where the Fall Creek waterfall plunges into the South Fork Snake River up to 8200 feet along Fourth of July Ridge (USGS 1996). Aspects tend to face either northeast or southwest due to the overthrust belt structure. Slope aspect affects the moisture content of soils. In general, the southwest-facing slopes are drier and less vegetated due to increased evapotranspiration than the wetter northeast-facing slopes.

Soils in the Caribou Range are relatively fertile, with enough mineral content to support adequate vegetation for ground cover to prevent erosion. Clay and silt derive from the sedimentary parent material of shale, limestone or siltstone. Sandy soils derive from conglomerate and sandstone sedimentary layers and have a higher erosion potential (Soil Conservation Service 1981 (now known as the Natural Resources Conservation Service).

On the steepest slopes, greater than 40% grade, the soils are generally deep, well-drained, stony-silty loams with frequent rock outcroppings on mountainsides. These soils are not suitable for building sites, recreational activities, crops, pasture, or rangelands due to the high risk of erosion caused by such activities. Natural erosion and mass wasting occurs where the soils are shallower over bedrock. The relatively high fertility makes these soils types superior for wildlife habitat (SCS 1981, USFS Caribou-Targhee National Forest 2002).

More moderate slopes, less than 40% grade, have silt-loams and silty clay with fair rangeland productivity and some potential for irrigated crops (SCS 1981). However, crops are limited by the short growing season, as shown in the Land Use subsection (in Section 1.3). Soils with higher clay contents are more damaged by recreation and grazing. Excessive use may cause compaction and lower productivity for native vegetation. Without vegetation as a groundcover, the erosive potential of the soils increases.

Riparian soils are derived mainly from volcanic geologic parent materials, so these soils are the most fertile and productive in the Fall Creek watershed. The soils are very deep, but some areas are susceptible to down-cutting action by streamwater (USFS Caribou-Targhee National Forest 2002). Soil samples from Camp Creek and Fall Creek were collected (DEQ 2002). According to the Unified Soil Classification System (Department of the Navy 1982), the soils are classified as follows:

- Camp Creek = CL: silty clay; very dark grayish brown. 10-15% fine sand. Low plasticity. Some organics <5%.
- Fall Creek = CL-ML: clayey silt; very dark brown. Up to 15% fine sand. Low plasticity. Some organics <5%.

This classification indicates that the Fall Creek riparian soil sample does not have as many clay fines as the Camp Creek sample.

The riparian soil samples were sent to the University of Idaho Analytical Sciences Laboratory Holm Research Center for standard fertility testing. The test results follow:

- Camp Creek
  - pH 7.7
  - 4% organic matter
  - Available phosphorus = 40+ μg/g (micrograms per gram of soil)
  - Available potassium = 190 μg/g
  - Nitrogen as nitrate = 7.8 μg/g
  - Nitrogen as ammonium = 3.7 μg/g
- Fall Creek
  - pH 7.7
  - 3.6% organic matter
  - Available phosphorus = 21μg/g
  - Available potassium = 160 μg/g
  - Nitrogen as nitrate = 29 μg/g
  - Nitrogen as ammonium = 4.2 μg/g

In order to interpret the soil fertility results, Stukenholtz Laboratory, Inc. in Twin Falls, Idaho provides the following soil test level for soils with medium fertility:

- pH = 5.6-7.0
- Organic matter = 1.1-1.7 %
- Available phosphorus = 9-20 μg/g
- Available potassium = 100-190 μg/g
- Nitrogen as nitrate = 6-15 μg/g

Relative to medium fertility, the riparian soils in Camp and Fall Creeks are:

- high in pH, or alkaline;
- high in organic matter;
- excessively high in available phosphorus in Camp Creek
- high in available phosphorus in Fall Creek;
- medium in potassium;
- medium in nitrate in Camp Creek;
- and high in nitrate in Fall Creek.

During a streambank erosion inventory in an upper reach of Fall Creek (DEQ 2002), excess nutrient accumulation was observed in the form of algal mats. The excess nutrients in the rich volcanic riparian soils may explain the algal growth, since in general the water quality did not appear to be impaired due to excess nutrient accumulation. The algal mats were isolated and not an overall nuisance accumulation.

Vegetation

The Fall Creek watershed is roughly 60% forested and 40% nonforested in both the Northern Basin and Range and the Middle Rockies ecosystems. Vegetation types vary depending upon soils, elevation, slope gradient and aspect of the watershed. In general, forests interspersed with alpine meadows occur at the higher 6,000 to 8,000 foot elevation zone. From 5,200 to 6,000 feet, brushlands and grasslands occur on drier slopes while mountain brush types occur on wetter slopes (Omernik and Gallant 1986). Calculations from Geographical Information Systems (GIS) coverages show 14 square miles of the western part of the watershed as Northern Basin and Range ecosystem and the remaining 64 square miles as Middle Rockies ecosystem. In reality, the ecotypical plant communities vary in patches according to elevation and aspect throughout the watershed (extrapolated from BURP data, DEQ 1993, 1996, 2001).

In 1997, the Targhee National Forest (TNF) estimated that as much as 99% of the conifer forests throughout the Forest were in a mature age class (USFS TNF 1997). In 2001, the Caribou-Targhee National Forest made a more specific study of the Fall Creek watershed in particular and found that the forests are all showing signs of late seral stages, reporting as follows: "Douglas-fir is becoming more predominant as it encroaches on stands of lodgepole pine and aspen, or shrubs. Evidence of insect attacks is readily visible in the Douglas-fir type and is increasing each year. It is likely that there is more Douglas-fir here now, and less aspen, lodgepole pine and shrublands, than historically. Fires have been suppressed for many years. Because stands are scattered and difficult to access, this condition is likely to persist. Treatment opportunities center around prescribed burns and limited vegetation treatment where access is more easily obtained. Most of the shrublands are also in late seral stages. Consequently, risks of large fires, insects and disease outbreaks are high" (USFS Caribou-Targhee National Forest 2002).

A range of climatic conditions produced by the variable topography allows the development of a biogeographical range from subalpine meadows to dry shrublands. At the highest altitudes from 6,000 to 10,000 feet, with the accompanying elevated moisture, cool temperatures and short growing seasons, the subalpine zone is dominated by subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). At lower elevations, upland slopes that are still somewhat moist and cool are populated by Douglas-fir (*Pseudotsuga menziesii*) communities. After disturbance in subalpine or montane zones, quaking aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) begin to establish. Mountain brush predominates on drier upland slopes. Curlleaf mountain mahogany (*Cercocarpus ledifolius* var. *intercedens*) and various sagebrush communities are found on southern slopes. On north slopes, black chokecherry (*Prunus virginiana* var. *melanocarpa*), Saskatoon serviceberry (*Amelanchier alnifolia*), antelope bitterbrush (*Purshia tridentata*), and Rocky Mountain maple (*Acer glabrum*) are found depending upon elevation. On the lowest, driest slopes, various sagebrush communities are interspersed with grasslands (USFS TNF 1997 and USFS CNF 1999).

Vegetation growing along the edges of streams (i.e., the riparian zone) helps to stabilize the soil of the streambanks. Riparian vegetation in the Fall Creek watershed commonly consists of grasses, forbs, and willows (*Salix* sp.). Shade-loving species present that tolerate wet soils include red-osier dogwood (*Cornus sericea*), various sedges (*Carex* spp.), black hawthorn (*Crataegus douglasii*), and water birch (*Betula occidentalis*). Overstory species commonly include Douglas-fir and quaking aspen. In lower altitudes with drier aspects, drought-tolerant shrubland species appear along the streambanks, including sagebrush (*Artemisia* spp.), bunchgrasses, rabbitbrush (*Chrysothamnus nauseosus* and *C. virginiana*) and antelope bitterbrush. Physical habitat descriptions by DEQ (1996, 2001) detail plant species growing along the streambanks that were monitored:

- Camp Creek at 6120 feet elevation includes quaking aspen, willow, and some water birch in the riparian area.
- Monument Creek at 6160 feet contains sedges, grasses, forbs, and willows in the riparian area.
- June Creek at 6080 feet has willow, grasses, and forbs.
- Trail Creek at 6160 feet has willow, grasses, and forbs.
- Gibson Creek at 5920 feet contains willow, grasses, forbs, and some sagebrush where the stream has impinged on the upland area.
- South Fork Fall Creek in the upper reaches at 6240 feet includes dogwood, willow, grasses, and forbs in the riparian area.
- South Fork Fall Creek in the lower reaches from 5520 to 5560 feet contains grasses, forbs including berry bushes, willow, dogwood, and rabbitbrush in the riparian area.
- Upper Fall Creek at 7120 includes grasses, forbs, quaking aspen, and Douglas-fir in the riparian area.
- Lower Fall Creek from 5720 to 5460 feet in elevation contains mainly willow, grasses, and forbs in the riparian area.

Fisheries and Aquatic Fauna

The number and variety of fish species in the Palisades subbasin are influenced naturally by Shoshone Falls near Twin Falls, Idaho. Representatives of the sucker family (Catostomidae), sculpin family (Cottidae), minnow family (Cyprinidae), as well as the trout and salmon family (Salmonidae) are known to occur. Suckers reported in the subbasin include the bluehead sucker (*Catostomus discobolus*), mountain sucker (*C. platyrhynchus*), and Utah sucker (*C. ardens*). Sculpins in the subbasin include the mottled sculpin (*Cottus bairdi*) and the Paiute sculpin (*C. beldingi*). Minnows reported in the subbasin include the longnose dace (*Rhinichthys cataractae*), redside shiner (*Richardsonius balteatus*), speckled dace (*Rhinichthys osculus*), and Utah chub (*Gila atraria*). The leatherside chub (*Gila copei*) is reported from Jackknife Creek, a tributary of the Salt River, which flows into Palisades Reservoir. Leatherside chub could easily occur in the Palisades subbasin as well. Species of the family Salmonidae reported in the subbasin include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), cutthroat trout (*Oncorhyncus clarki sp.*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*O. mykiss sp.*), and cutthroat trout-rainbow trout hybrids. See Table 4 for the species found particularly in the Fall Creek watershed of the Palisades subbasin. These occurrence reports are taken from Lee and others (1980), Simpson and Wallace (1982), Baxter and Stone (1995), Maret (1997), and the data sources listed in Table 4. No bull trout (*Salvelinus confluentus*) are known to occur in the Palisades subbasin.

Table 4. Occurrence of fish and number of salmonid age classes in the Fall Creek watershed.

Waterbody	CTT[1]	BRK[2]	RBT[3]	Non-salmonids	Comments	Data Source
Camp Creek	X[4]	?	X	?	CTT/RBT hybrid	DEQ 2002
Fall Creek	X	?	?	?	Stocked RBT	Moore 1980
Fall Creek	?	?	?	?	Stocked RBT	Moore and Schill 1984
Fall Creek	2+/J[5]	?	?	dace, sculpins, shiners	-	Elle and Corsi 1994
Fall Creek	3	3+/J	?	sculpins, longnose dace, speckled dace	-	TNF 1999
South Fork Fall Creek	?	X	?	*Cottus bairdi*	-	DEQ 2001
Gibson Creek	1/J	3	?	?	-	DEQ 1996

[1]CTT: cutthroat trout
[2]BRK: brook trout
[3]RBT: rainbow trout
[4]X = presence
[6]J = juveniles present

Yellowstone cutthroat trout (*O. c. bouvieri*) is the species of greatest concern in the Fall Creek watershed. May (1996) reports that, in Idaho, only ten percent of the population of Yellowstone cutthroat trout are secure and stable. The historic range of the Yellowstone cutthroat trout is estimated to occupy 41% of the riverine environments of Idaho (May 1996). A primary objective of the Idaho Department of Fish and Game (IDFG) is to "preserve the genetic integrity and population viability of wild native cutthroat trout" in the South Fork Snake River drainage

(IDFG 1996). Stocking of rainbow and brown trout was discontinued in the early 1980s to reduce competition with Yellowstone cutthroat trout.

Stream Characteristics

The nature of individual streams in the Fall Creek watershed is described in DEQ data collected by BURP crews working for the Idaho Falls Regional Office (DEQ 1993, 1996, 2001). Rosgen classifications are based on the system developed by Dave Rosgen for characterizing streams according to geomorphology (Rosgen 1996). Rosgen type A streams are steep gradient, high energy streams with cascades and pools. Rosgen type B streams are more moderate gradient, very stable streams dominated by riffles. Rosgen type C streams are low gradient meandering streams with point bar development and are characterized by riffles and pools.

Physical habitat descriptions of the streams sampled by the BURP protocol follow:

- Camp Creek at 6120 feet elevation is a first-order stream in a Rosgen type B channel in a V-shaped valley with moderate sinuosity and a 4% gradient.
- Monument Creek at 6160 feet is a first-order stream in a Rosgen type B channel in a trough-like valley with moderate sinuosity and a 5% gradient.
- June Creek at 6080 feet is a first-order stream in a Rosgen type B channel in a trough-like valley with low sinuosity and a 2% gradient.
- Trail Creek at 6160 feet is a first-order stream in a Rosgen type B channel in a trough-like valley with moderate sinuosity and a 3% gradient.
- Gibson Creek at 5920 feet is a first-order stream in a Rosgen type A channel in a trough-like valley with moderate sinuosity and a 7% gradient.
- South Fork Fall Creek in the upper reaches at 6240 feet is a third-order stream in a Rosgen type B channel in a V-shaped valley with moderate sinuosity and a 4% gradient.
- South Fork Fall Creek in the lower reaches from 5520 to 5560 feet is a third-order stream in a Rosgen type C channel in a V-shaped valley with moderate sinuosity and a 2% gradient.
- Upper Fall Creek at 7120 feet is a first-order stream in a Rosgen type A channel in a V-shaped valley with moderate sinuosity and a 16% gradient.
- Lower Fall Creek from 5720 to 5460 feet in elevation is a fourth-order stream in a Rosgen type C channel in a V-shaped valley with moderate sinuosity and a 2% gradient.

Further observations by DEQ in 2002 identify Fall Creek as a typical beaver complex scenario, with a meandering stream in a broad valley and a series of pools created by beaver dams. There are very few riffles in the stream, streamflow being predominantly one pool pouring over a beaver dam into another pool. More detailed observations of the listed portions of Fall Creek and Camp Creek are recorded in Section 3--Watershed Assessment--Pollutant Source Inventory.

1.3 Cultural Characteristics

Land Use

Fall Creek watershed is a mix of forested areas and rangeland. The area is very rural with good wildlife habitat high in the hills where motorized travel does not interfere. Humans use the Fall Creek watershed mainly for recreational activities and for rangeland to graze sheep and cattle.

There are only 50 reliably frost-free days, so spring barley would be the most successful crop in the limited growing season available to the Fall Creek watershed (SCS 1981). However, there are only four acres used for dryland agriculture in the lowest part of the Fall Creek drainage with the remainder in forested acreage and grazed rangeland (Idaho Water Resource Board 1996).

The GIS coverages (Idaho Water Resource Board 1990) show just over four acres of the watershed used for rangeland, four acres for dryland agriculture, and the remainder used as forest. However, in reality the entire watershed is parceled into grazing allotments, so grazing is the predominant land use in the Fall Creek watershed. Grazing allotments are managed in an effort to reduce sediment loading to the streams. Current conditions of grazing allotments in the Fall Creek watershed are given in Table 5, which is excerpted from the rangelands section of the Current Conditions chapter in "Fall Creek Watershed Analysis: Palisades Ranger District, Caribou- Targhee National Forest" (USFS Caribou-Targhee National Forest 2002).

Table 5. Grazing allotments in Fall Creek watershed.

Allotment name	Season of use	Permitted number of livestock	Grazing system
Fall Creek	Jun 6 - Oct 10	784 cows	Modified five-pasture rotation; three units are deferred and two are rested
Snake River	Jun 1 - Oct 15	623 cows	Modified rest rotation
Beaver Commissary	Jun 26 - Sep 15	1000 sheep	Four pasture rest rotation
Golden Gate	Jul 6 - Sep 15	1000 sheep	Six pasture rest rotation
Home Ridge Red Peak	Jun 26 - Sep 9	1200 sheep	Four pasture rest rotation
Lone Pine	Sep 1 - Oct 1 Sep 10 - Oct 1	1500 sheep 1200 sheep	Deferred rotation (Ewes only)
Mahogany Ridge	Jun 16 - Aug 30	1200 sheep	Four pasture rest rotation
Point Lookout	Jun 16 - Aug 30	1000 sheep	Deferred rotation (rested due to prescribed fire in Garden and Pritchard Creeks)

Land Ownership, Cultural Features, and Population

The Fall Creek watershed lies entirely within Bonneville County. The nearest incorporated town is Swan Valley, lying 2 miles across the South Fork Snake River from the mouth of Fall Creek. Swan Valley has a population of 213 with some commercial activity along the main route US Highway 26, but with otherwise rural occupations (Idaho Data Center 2002).

Only 1.7 square miles of land in the watershed are in private ownership, and the remaining 76 square miles are in public ownership, managed by the Caribou-Targhee National Forest, Palisades Ranger District, headquartered in Idaho Falls. The private land occurs in 0.47 square miles at the mouth of Fall Creek, 1.01 square miles at the Camp Creek confluence with Fall Creek, and 0.21 square miles at the headwaters of Trail Creek (Calculated from GIS coverages, Idaho Water Resource Board, 1992). The Bagley Ranch is near the mouth of Fall Creek and is used for dryland agriculture. The Quarter Circle O Ranch has a property of about 640 acres in the upper Fall Creek basin. The owners would like to trade the property for USFS land elsewhere to allow the prime wildlife habitat to remain undeveloped (USFS Caribou-Targhee National Forest 2002).

Mining has had very little impact in the watershed. There have been a few phosphate exploration digs near Fall Creek. An open-pit travertine rock mine is located in Echo Canyon in the lower Fall Creek drainage on a 60-acre parcel (USFS Caribou-Targhee National Forest 2002).

The USFS Fall Creek Watershed Analysis indicates that a Bonneville Power Authority powerline that parallels Fall Creek is ". . . a major special use in the area is a and has resulted in access roads to the power poles. More are being built currently. These roads are not counted in the Forest Travel Maps or road density reports since they are administratively closed. However, there are no barriers or gates controlling access at this time. The BPA powerline access roads especially impact Rash Canyon on Fall Creek because there is a new powerline road built off of Rash Canyon Road to access power poles on the BPA line in Fall Creek." (USFS Caribou-Targhee National Forest 2002).

2. Watershed Assessment - Water Quality Concerns and Status

Monitoring performed by DEQ has identified water quality concerns in the Fall Creek watershed. Due to low macroinvertebrate biotic index scores, Idaho determined that all of Camp Creek and the upper portion of Fall Creek have impaired water quality by not fully supporting the beneficial use of cold water aquatic life.

2.1 Water Quality Limited Segments Occurring in Fall Creek Watershed

The 1998 303(d) list for Idaho (DEQ 1999) designates two waterbodies in the Fall Creek watershed as water quality limited, as shown in Table 6. The listed portions of the Fall Creek watershed are also shown above in Figure 2. The EPA has added over 92 water bodies to the 1998 Idaho 303(d) list (EPA 2000), primarily for elevated surface water temperatures. However, the Camp Creek and Fall Creek segments were added to the 1998 303(d) list due to an unknown pollutant.

Table 6. Section 303(d) Segments in the Fall Creek Watershed.

Waterbody Name	WQL SEG	Assessment Units	1998 §303(d) Boundaries	Pollutants	Listing Basis
Camp Creek	5240	ID17040104SK006-02	headwaters to Fall Creek	Unknown	low stream macroinvertebrate index score
Fall Creek	5247	ID17040104SK006-03 ID17040104SK006-04	headwaters to SF Fall Creek	Unknown	low stream macroinvertebrate index scores

2.2 Water Quality Standards--Beneficial Uses

Idaho water quality standards are published in Idaho's rules at IDAPA 58.01.02. They require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). Beneficial uses are the characteristics of Idaho's streams to be utilized for various purposes, and support status is defined at IDAPA 58.01.02.053. The Water Body Assessment Guidance, second edition (Grafe et al. 2002) gives a more detailed description of the procedure for assessing beneficial uses. Beneficial uses are categorized as existing uses, designated uses, and presumed uses.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards." The existing uses in stream water and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.003.35, .050.02, and 051.01 and .053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. Practical application of this concept would be when a water contains juvenile trout indicating that salmonid spawning is occurring.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each waterbody or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include things like cold water aquatic life, recreation in and on the water, domestic water supply, and agricultural use. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for waterbodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.22 and .100, and IDAPA 58.01.02.109-160 in addition to citations for existing uses.)

Presumed Uses

In Idaho, most waterbodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric criteria cold water and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen, temperature). However, if for example, cold water is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria. (IDAPA 58.01.02.101.01).

Surface water use designations are given in IDAPA 58.01.02.100-160 for waters of Idaho. Table 7 shows the extract of this rule section that includes waters of the Fall Creek watershed. Although Camp Creek is on the 303(d) list, it does not have a use designation in the water quality standards.

Table 7. Fall Creek watershed surface water use designations.

Waterbody	Water Body Unit	Boundaries	Designated Uses	1998 §303(d) List
Fall Creek	US-5	SF Fall Creek to mouth	Cold water aquatic life, Salmonid spawning	No
Fall Creek	US-6	source to SF Fall Creek	Cold water aquatic life, Salmonid spawning	Yes
South Fork Fall Creek	US-7	source to mouth	Cold water aquatic life, Salmonid spawning	No

According to the water quality standards, cold water aquatic life and salmonid spawning are designated beneficial uses that should be supported in the Fall Creek watershed.

2.3 Summary and Analysis of Existing Water Quality Data

Since the Fall Creek watershed is rural and remote from any population centers of Idaho, it is not undergoing any DEQ long-term water quality monitoring projects. The USFS has a long-term temperature monitoring project in place. All water quality data used in determining support of beneficial uses were collected by the USFS and DEQ, either by BURP crews in 1993, 1996, and 2001, or by State Office staff in 2002.

Flow Characteristics

There are no current realtime gages measuring water levels in the Fall Creek drainage. Historical data from one USGS gage measured streamflow on Fall Creek during 1917, 1918, 1934, 1935, and 1936. Refer to Table 2 for the available streamflow statistics during the measurement period. Available data from April through October indicate 75% of the streamflow occurring in April, May and June (USGS 2002). These data support the conclusion that snowmelt and spring runoff contributes the most significant portion of surface water in the Fall Creek drainage.

Instantaneous flow measurements were acquired during beneficial use reconnaissance by DEQ. Refer to Table 3 for the instantaneous flow measurements recorded by Beneficial Use Reconnaissance Program (BURP) crews from the DEQ Idaho Falls Regional Office (DEQ 1993, 1996, 2000). These data agree that South Fork Fall Creek contributes more than half of the stream discharge to the Fall Creek watershed.

Water Column Data

No chemical data (other than temperature measurements) have been collected from the Fall Creek watershed. In this rural area, there are neither point sources nor activities that could contribute hazardous substances to the streams.

Although water column information is delineated in surface water quality criteria for aquatic life use designations, biological monitoring is used by DEQ to assess the impairment of surface waters. General criteria in IDAPA 58.01.02.250.01 designate levels for hydrogen ion concentration, dissolved gases, and total chlorine residual. Cold water criteria in IDAPA 58.01.02.250.02 specify:

- dissolved oxygen concentrations;
- water temperatures for cold water aquatic life;
- ammonia levels;
- turbidity; and
- salmonid spawning characteristics including:
  - intergravel dissolved oxygen;
  - water column dissolved oxygen; and
  - water temperatures for salmonid spawning.

Whereas sampling for water column data could identify water quality at one point in time, sampling the life forms that live in the water column gives a long term picture of water quality during the life cycle of the aquatic life form. For instance, redside shiners and speckled dace are Idaho native species that are tolerant of pollutants in the water. Bull trout are very sensitive to impaired water quality. In this example, if a stream is located in a habitat where Bull trout should be present, but the fish collections show only shiners or dace and no trout, then water quality may be impaired. (Refer to Zaroban et al. 1999 for specific tolerances of freshwater fish species known to occur in Idaho.) Both fish and macroinvertebrate populations have proved valuable to describe the quality of surface waters. Therefore, DEQ does not invest as much time sampling for water column information as for biological assemblages.

Temperature Data

Stream temperatures were monitored by the USFS in Fall Creek near Little Currant Creek during 2001, 2002, and 2003. These data show a consistent pattern of water temperatures increasing rapidly reaching a peak of about 24°C in July and then slowly decreasing through August and September (see Appendix D). Highest water temperatures experienced each year are shown in Table 8.

Table 8. The highest water temperature recorded each year during the spring salmonid spawning period in Fall Creek from 2001 through 2003.

	2001	2002	2003
Highest Water Temperature Recorded	24.61°C	22.06°C	20.97°C
Percent Over 13°C Criterion	47%	41%	38%
Date Occurred	July 1st	June 30th	June 30th

The default spring spawning season for cutthroat trout is April 1 to July 1 (Grafe et al., 2002). Therefore, exceedances of the salmonid spawning criteria are evaluated for the recording period from whenever the recording device is put in (usually end of June) to July 1. Table 8 shows that water temperatures in Fall Creek exceed the 13°C salmonid spawning criterion by 38 to 47% in the early weeks of July.

The default fall spawning period for brook trout is from October 1 to June 1. No temperature data are available for that time period, thus the fall spawning period cannot be evaluated.

Biological Data

Streams in this subbasin were originally assessed through the DEQ Beneficial Use Reconnaissance Project (BURP) and the 1996 Water Body Assessment Guidance or “WBAG 1” as it is called (IDEQ, 1996) plus any additional information. For all of these streams, macroinvertebrate index scores (MBI) were calculate (see Table 9). From this analysis, streams were determined to be “full support,” “needs verification,” or “not full support” for cold water biota based on these scores.

Early in 2002, the second edition of DEQ’s Water Body Assessment Guidance was released (Grafe et al. 2002). This WBAG II protocol modified considerably the process by which streams are assessed for support of beneficial uses. Specifically, multimetric indices were changed as more data were added since WBAG 1 was published. A process was put in place where macroinvertebrate, habitat, and fish indices are scored and then averaged to produce a single score from “minimum threshold” to 3 where streams must score a 2 or higher to be considered fully supporting their aquatic life uses. Data from BURP sites in this subbasin were re-evaluated using this new WBAG II system. Those scores for Fall Creek and Camp Creek are also listed in Table 9.

Table 9. Beneficial Use Reconnaissance Project sites for Fall Creek and Camp Creek and their associated assessment scores.

BURPID	STREAM	DATE SAMPLED	MBI	SMI	SMI score	SHI	SHI score	Ave Score
1993SIDFA016	FALL CK #2 UPPER	7/21/93	3.31	35.38	1	19	1	1
1993SIDFA017	FALL CK #1 LOWER	7/21/93	2.72	23.06	min	15	1	min
1996SIDFY014	FALL CREEK	6/5/96	1.98	14.94	min	60	2	min
1996SIDFY017	FALL CREEK	6/6/96	2.81	32.79	min	37	1	min
1996SIDFY030	CAMP CREEK (1)	6/19/96	1.96	25.99	min	56	1	min
1996SIDFY032	FALL CREEK	6/20/96	4.86	60.13	3	51	1	2

MBI = macroinvertebrate biotic integrity index from WBAG 1process.
SMI and SMI score = stream macroinvertebrate index and relative score from WBAG II process.
SHI and SHI score = stream habitat index and relative score from WBAG II process.
Min = minimum threshold, any score less than one automatically results in impaired use status regardless of other index scores.
Ave. Score = the average between the SMI score and the SHI score.

Insufficient information exists to calculate a stream fish index (SFI), so support status is based on the average of the macroinvertebrate (SMI) and the habitat (SHI) scores. According to the WBAG II process, any average score less than 2 indicates that the aquatic life use is impaired. The MBI scores used in the older WBAG 1 assessment process would have identified three sites on Fall Creek as "Needs Verification" because MBI scores were between 3.5 and 2.5. The 1993 data was not used in the WBAG II process because the information is greater than 5 years old, however the overall result would probably have been the same. The data in Table 9 suggest that all sites but one on Fall Creek are impaired, as is the one site on Camp Creek impaired (Table 10). Fall Creek above the South Fork and Camp Creek are not fully supporting aquatic life uses according to the assessment. Although one BURP site had good scores in Fall Creek below the South Fork, it was decided to continue the TMDL to the mouth of Fall Creek due to the observed condition of the creek and its banks in that area.

Macroinvertebrates

Macroinvertebrate assemblages were collected by BURP crews in Camp Creek and Fall Creek during the 1996 field season (DEQ 1996). When the macroinvertebrate data were assessed, Camp Creek and Fall Creek were added to the 1998 303(d) list based on low index scores due to an unknown pollutant (EPA 2000). A biotic integrity report for Palisades subbasin identified fine sediment as the pollutant limiting macroinvertebrate populations in Camp Creek and Fall Creek (Clark 2000). The excerpted data from the biotic integrity report are presented in Appendix A. The BURP data for Camp Creek indicate beneficial uses for cold water aquatic life not fully supported. The BURP data for Fall Creek indicate beneficial uses for cold water aquatic life not fully supported. These beneficial use determinations are summarized in Table 10.

Table 10. Fall Creek watershed macroinvertebrate summary

Waterbody/ Site ID	Location	Beneficial Uses for Cold Water Aquatic Life
Camp Creek/ 1996SIDFY030	30 m above crossing	Not full support
Fall Creek/ 1996SIDFY014	300 m below Basin trail	Not full support
Fall Creek/ 1996SIDY017	300 m above Monument Creek	Not full support
Fall Creek/ 1996SIDFY032	0.5 mi above Currant Hollow	Not full support

Clark (2000) evaluated the macroinvertebrate assemblages and determined that Camp Creek and the upper site (1996SIDFY014) where Fall Creek is a first order stream, are impaired by fine sediment.

Fish

Fish data available in the Fall Creek watershed are detailed in Table 4 of the watershed characterization section. In summary of the data shown in Table 4, Fall Creek contains three age classes of adults as well as juveniles for both Yellowstone cutthroat trout and brook trout. An examination of Idaho Fish and Game (IDFG) records shows that salmonids have not been stocked in Fall Creek since rainbow trout were stocked in 1984 (Moore and Schill 1984). In the absence of stocked salmonids, one age class indicates availability of spawning habitat, and two age classes indicate the availability of rearing habitat. Salmonid spawning waters are defined in the water quality standards as ". . .waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes" (IDAPA 58.01.02.100.01.b). Since Fall Creek is not stocked and contains three age classes plus juvenile salmonids, spawning and rearing habitat are both available. Therefore, Fall Creek has active self-propagating populations of salmonid fishes. Salmonid spawning use is considered not fully supported by default when cold water aquatic life use is not fully supported (Grafe et al. 2002), plus there are spawning temperature criteria violations.

Camp Creek contains one age class of a cutthroat/rainbow hybrid trout. The hybrid trout was the sole specimen collected during 242 seconds of electrofishing effort by DEQ staff in Camp Creek on August 21, 2002. It was 170 millimeters long, and collected upstream from Forest Route 376. The hybrid trout was identified by DEQ Certified Fisheries Specialist Don Zaroban. An examination of IDFG records shows that no salmonids have been stocked in Camp Creek. In the absence of stocked salmonids, one age class indicates availability of spawning habitat in Camp Creek. Salmonid spawning use in Camp Creek is also considered not fully supported by default.

Status of Beneficial Uses

Current aquatic life beneficial use status in Fall Creek watershed follows:

- Camp Creek
  - Cold water aquatic life is "Not Full Support" due to fine sediment; and
  - Salmonid spawning is by default "Not Full Support."

- Fall Creek, East Fork to mouth
  - Cold water aquatic life is "Not Full Support" due to fine sediment; and
  - Salmonid spawning is "Not Full Support due to temperature."

Water Quality Standards Applicable to Sediment as a Pollutant

Data collection and analysis by DEQ shows that the general surface water criteria for sediment are not being met. The "General Surface Water Criteria" for sediment (IDAPA 58.01.02.200.08) are that sediment shall not exceed quantities, which impair beneficial uses. Since excessive sediment in surface water derives from nonpoint sources, impairment of beneficial uses shall be determined based on the results of water quality monitoring and surveillance as described in the "Rules Governing Nonpoint Source Activities" in IDAPA 58.01.02.350. If monitoring and surveillance shows that beneficial uses are being impaired, then DEQ may develop and recommend control measures necessary to fully protect the beneficial uses (IDAPA 58.01.02.350.02.b.ii.2).

In compliance with the requirement for control measure development, the USFS has done an evaluation of the Fall Creek watershed (USFS Caribou-Targhee National Forest 2002) and made recommendations for modified practices in section 7 of the Fall Creek Watershed Analysis. The DEQ review projects to insure that the project plans contain:

- compliance with either approved or specialized best management practices;
- a monitoring plan; and
- a process for modifying the approved or site-specific best management practices in order to protect beneficial uses of the Fall Creek watershed.

Water Quality Standards Applicable to Salmonid Spawning Temperature

Water quality standards for temperature are specific numeric values not to be exceeded during the salmonid spawning period. For Fall Creek the principle salmonid of interest is cutthroat trout, that has a default spawning period recognized by DEQ as from April 1st to July 1st each year (Grafe et al., 2002). As per IDAPA 58.01.02.250.02.e.ii., the water quality criteria that need to be met during that time period are:

> 13^oC as a daily maximum water temperature,
> 9^oC as a daily average water temperature.

For the purposes of a temperature TMDL, the highest recorded water temperature in a recorded data set (excluding any high water temperatures that may occur on days when air temperatures exceed the 90th percentile of highest annual MWMT air temperatures) is compared to the daily maximum criterion of 13^oC. The difference between the two water temperatures represents the temperature reduction necessary to achieve compliance with temperature standards.

3. Watershed Assessment-Pollutant Source Inventory

3.1 Sources of Pollutants of Concern

The Fall Creek watershed stream segments listed for unknown pollutants have been investigated by DEQ staff and determined to be impacted by sediment. Results of the investigation indicate that activities associated with recreation and rangeland land uses contribute excess sediment to the surface water (DEQ 2002).

<u>Point Sources</u>

There are no Superfund or RCRA sites in the Fall Creek watershed. There are no national pollution discharge elimination system (NPDES) permitted point sources, neither are there any potentially unpermitted point sources in this area. There are no confined animal feeding operations (CAFOs). Since there are no known point sources, no wasteload allocations (WLA) shall be developed for point sources.

<u>Nonpoint Sources</u>

Activities observed in the Fall Creek watershed include grazing, roads and trails for motorized vehicles traversing the streambanks via unimproved fords, recreational vehicles parked in riparian areas, and bare compacted streambanks at campsites. Among these activities, the dominant nonpoint sources of sediment are grazing and motorized vehicle travel. Observations and measurements of streambank stability and water quality were made by DEQ staff while monitoring streams in the Fall Creek watershed (DEQ 2002). Sediment is identified as the pollutant of concern.

Temperature data on Fall Creek near Little Currant Creek(M. Philbin pers. comm.), approximately 2.5 miles upstream from the mouth, shows exceedances for salmonid spawning criteria (see data in Appendix D). This site is presumably above geothermal hot springs that flow into Fall Creek. Observations made in 2002 shows that as South Fork Fall Creek cools and becomes frozen with lowered air temperatures, temperatures in lower Fall Creek remain elevated due to the geothermal features.

Camp Creek

Camp Creek is impacted by sediment from cattle grazing in the riparian area and trampling the streambank. Specific observations made in the reach from Forest Route 376 to the confluence with Fall Creek indicate that often when cattle trail near the Camp Creek streambank, the banks are more unstable, cracking and crumbling into the stream channel. A typical section of this reach of Camp Creek is shown in Figure 4.

Photo by Don Zaroban August 21, 2002.

Figure 4 Camp Creek Bank Erosion

Evidence of old meanders was apparent, where old, browsed riparian willows are now in the upland region outside the riparian zone and upland forbs like cinquefoil (*Potentilla* spp.) are growing into the old riparian meander zone. The old meanders are now eliminated by severe downcutting as shown in Figure 4. Meanders lessen and downcutting increases incrementally downstream all the way to the confluence with Fall Creek. In effect, this increases the energy potential of a high streamflow during a spring runoff event. A high streamflow would deliver significantly more sediment in this system than in the naturally-functioning system of meanders where the meander curves would dissipate the high-energy streamflow and allow more sediment to be captured instead of delivered to Fall Creek below. (See Rosgen 1996 for relation of geomorphic integrity to erosive potential of stream discharge).

Road crossings in Camp Creek also contribute to riparian degradation and increase the sediment load. Figure 5 shows Forest Route 376 crossing Camp Creek. From this road crossing downstream to the confluence with Fall Creek, there were two more recreational roads crossing via unimproved fords through the stream channel.

Photo by Don Zaroban August 21, 2002.

Figure 5 Forest Route 376 Through Camp Creek

In this reach, most of the excess sedimentation is riparian in origin from cattle trampling streambanks and motorized traffic crossing the stream at unimproved fords. However, there is also some potential for upland erosion. There are two headcuts in Camp Creek that can deliver upland sediment. Also, there are three perennial mineral seeps. Since the water oozes continuously, cattle walk across the softened ground and create a quagmire of mud, eliminating the vegetated ground cover and increasing the erosion potential.

Above Forest Route 376, a streambank erosion inventory was performed according to modified Natural Resources Conservation Service (NRCS) protocols (NRCS 1983). The location of the inventory is shown in Figure 12 of Appendix B. The raw data generated from the streambank erosion inventory and the data analysis are also presented in Appendix B. General observations of this reach include old unconsolidated log jams and beaver dams that are raising the level of the stream. Because of grazing in the streambanks, these areas are becoming increasingly unstable and are due for headcutting. The entire reach is erosive with crumbling, cracking, slumping banks, hoof-sheared banks, and trampled bare banks.

This investigation concluded that the watershed would benefit from sediment load reductions. Human activities have impaired water quality and management may reduce the sediment load being delivered to Fall Creek.

Fall Creek

Two streambank erosion inventories were performed according to modified NRCS protocols (NRCS 1983). Data from the upper and lower Fall Creek streambank erosion inventories are given in Appendix B and the location of the inventories are shown in Figure 12 of Appendix B. In general, these investigations show that Fall Creek is impacted by sediment from cattle grazing and trampling the riparian zone and also by motorized vehicle travel.

From the headwaters to the East Fork confluence, which is above the upper Fall Creek streambank erosion inventory, Fall Creek is a first-order stream with willow thickets covering stable streambanks. (See Figure 6.) This reach is not erosive and Fall Creek will be removed from the 303(d) list from its headwaters to the East Fork confluence (DEQ 2002).

Photo by Tom Herron October 8, 2002.

Figure 6. Representative of Fall Creek above East ForkConfluence.

In the upper Fall Creek streambank erosion inventory, the stream is almost entirely a beaver complex, with pools formed from inactive beaver dams. A Forest Route that is now closed to motorized travel, stream meander and vegetation change have impacted the riparian zone. See Figure 7 for a large cut bank caused by the old road.

Photo by Tom Herron October 8, 2002.

Figure 7. Cut Bank in Fall Creek

Although the road is closed to motorized traffic, this and other hereditary cut banks can deliver excessive sediment during high streamflow events like spring snowmelt and runoff. Additionally, stream banks are trampled along the entire reach except for five stretches of willow thickets that are too thick for stream access by cattle. Excessive sediment is being delivered to the stream more than a well-functioning beaver complex could entrain, and Fall Creek exhibits an old, inactive beaver complex.

This investigation concluded that a sediment load allocation should be given to Fall Creek because it may be a significant source of sediment. The 303(d) listed reach should extend from East Fork to the mouth of Fall Creek. The potential for extensive sediment loading exists if the old beaver dams collapse. Human activities associated with recreational and rangeland land uses have impaired water quality in Fall Creek and management may reduce the sediment load being delivered to Fall Creek and the South Fork Snake River(see Figure 8).

Photo by Don Zaroban August 21, 2002.

Figure 8 The South Fork of the Snake River above Fall Creek.

4. Watershed Assessment – Summary of Past and Present Pollution Control Efforts

Past pollution control efforts on private lands have reduced sediment discharge to potentially affected streams (East Side Soil and Water Conservation District 1989, 1991). However, in the lowest part of the Fall Creek drainage there are only four acres used for dryland agriculture with the remainder in forest or rangeland (Idaho Water Resource Board 1990), so sediment reduction from cropland would have a negligible effect on Fall Creek. The Quarter Circle O Ranch owns 640 acres in the upper Fall Creek basin. The owners wish to trade the private property with USFS land elsewhere so the parcel will not be developed, thereby encouraging pollution prevention by maintaining habitat integrity (USFS Caribou-Targhee National Forest 2002).

Pollution control efforts on public lands have been geared toward maintaining the integrity of streambanks to reduce sediment loading. The USFS manages livestock grazing, recreational activities, fire regimes, and road densities in an attempt to reduce sediment impacts to streams. The Fall Creek watershed analysis completed by the Caribou-Targhee National Forest in January 2002 describes several pollution control projects implemented to improve streambank conditions and reduce sediment loading in Fall Creek. Past projects described include:

- In 1961, a range enhancement project in the Fall Creek watershed occurred wherein sagebrush was sprayed with 2,4-D to encourage more grass growth and fences were constructed to allow rest rotation management of cattle grazing allotments.
- In 1966, after the Currant Creek fire in the lower Fall Creek canyon, the burnt area was seeded.
- In 1982, volunteer boy scouts planted willows and built fences along Fall Creek.
- In 1993, the Palisades Ranger District began an extensive streambank stabilization project for Fall Creek. The District built green tree revetments to stabilize cut banks, placed rock and log structures in the stream to redirect stream flow, and fenced stream banks. Unauthorized trail and road developments were blocked and a beaver management program was established.
- Bonneville County continuously maintains the road paralleling Fall Creek, Forest Route 077. Riprap is applied to the stream banks where the road encroaches on the riparian area.
- Grazing allotments are managed in an effort to reduce sediment loading to the streams.
- BPA built a culvert across Fall Creek on a powerline road off of Rash Canyon Road that provides easier access up Rash Canyon and leads to a large network of legal and illegal motorized trails in the watershed (M. Philbin pers. comm.).

In August and October 2002, DEQ observed additional pollution control projects in the Fall Creek watershed. The USFS has placed barriers on trails made illegally by off-road vehicles in an attempt to prevent upland erosion. Illegal off-road use by all-terrain vehicles and snowmachine travel is discouraged by signs and law enforcement as the Forest budget allows (USFS Caribou-Targhee National Forest 2002).

5. Total Maximum Daily Loads

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, which receive a load allocation (LA). Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR 130) require a margin of safety (MOS) be a part of the TMDL.

In practice, the MOS is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the LC is determined. Then the LC is broken down into its components: the necessary MOS is determined and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation is completed we have a TMDL, which must equal the LC.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. Also a required part of the loading analysis is that the LC be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both LC and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads, and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 Instream Water Quality Targets

The sediment target for this TMDL will be a percentage of bank stability. The amount of sediment delivered to the stream depends on the amount of eroding stream bank. Eighty percent or less bank stability (≥20% eroding banks) is indicative of natural conditions and delivers a background or natural amount sediment to the stream. Any more eroding bank, as determined through bank erosion surveys, is considered detrimental.

For temperature, the instream targets are the salmonid spawning temperature criteria previously discussed.

Sediment Load Allocation Techniques

This section describes the analytical techniques and data used to develop the gross sediment budget and instream sediment measures used in calculating the load allocations for Camp Creek and Fall Creek. During the process of load allocation development, DEQ also investigates the natural condition of the stream channels and riparian zones in comparison to the existing condition. The load allocation process will also pinpoint the desired level of erosion and sedimentation and provide baseline data to track the effectiveness of TMDL implementation. The load allocation techniques can be repeated and ultimately provide an adaptive management or feedback mechanism.

The streambank erosion inventory used to estimate background and existing streambank erosion followed methods outlined in the proceedings from the Natural Resource Conservation Service (NRCS) Channel Evaluation Workshop (NRCS 1983). The NRCS streambank erosion inventory is a field method that estimates streambank and channel stability, length of active eroding banks, and bank geometry. The streambank and channel stability field measurements are used to evaluate the long term lateral recession rate. The rating factors and rating scores are:

Bank Stability:
- Do not appear to be eroding - 0
- Erosion evident - 1
- Erosion and cracking present - 2
- Slumps and clumps sloughing off - 3

Bank Condition:
- Some bare banks, few rills, no vegetative overhang - 0
- Predominantly bare, some rills, moderate vegetative overhang - 1
- Bare, rills, severe vegetative overhang, exposed roots - 2
- Bare, rills and gullies, severe vegetative overhang, falling trees - 3

Vegetation/Cover On Banks:
- Predominantly perennials or rock-covered - 0
- Annuals/perennials mixed or about 40% bare - 1
- Annuals or about 70% bare - 2

Predominantly bare - 3

Bank/Channel Shape:

V-shaped channel, sloped banks - 0
Steep V-shaped channel, near vertical banks - 1
Vertical banks, U-shaped channel - 2
U-shaped channel, undercut banks, meandering channel - 3

Channel Bottom:

Channel in bedrock/noneroding - 0
Soil bottom, gravels or cobbles, minor erosion - 1
Silt bottom, evidence of active downcutting - 2

Deposition:

No evidence of recent deposition - 1
Evidence of recent deposits, silt bars - 0

Cumulative Rating

Slight (0-4) Moderate (5-8) Severe (9+)

From the Cumulative Rating, the lateral recession rate is assigned.

0.01 - 0.05 feet per year	**Slight**
0.06 - 0.15 feet per year	**Moderate**
0.16 - 0.3 feet per year	**Severe**
0.5+ feet per year	**Very Severe**

Streambank stability can also be characterized through the following definitions. The corresponding streambank erosion condition ratings from bank stability factors are included in italics:

Streambanks are considered stable if they do not show indications of any of the following features:

- Breakdown - obvious blocks of bank broken away and lying adjacent to the bank breakage. *Bank Stability Rating 3*
- Slumping or false bank - bank has obviously slipped down, cracks may or may not be obvious, but the slump feature is obvious. *Bank Stability Rating 2*
- Fracture - a crack is visibly obvious on the bank indicating that blocks of the bank are about to slump or move into the stream. *Bank Stability Rating 2*
- Vertical and eroding - the bank is mostly uncovered and the bank angle is steeper than 80 degrees from the horizontal. *Bank Stability Rating 1*

Streambanks are considered covered if they show any of the following features:

- Ground cover with perennial vegetation greater than 50%. *Vegetation/Cover Rating 0*
- Roots of vegetation cover more than 50% of the bank (deeply rooted plants such as willows and sedges provide such root cover). *Vegetation/Cover Rating 1*

- At least 50% of the bank surfaces are protected by rocks of cobble size or larger. *Vegetation/Cover Rating 0*
- At least 50% of the bank surfaces are protected by logs of four-inch diameter or larger. *Vegetation/Cover Rating 1*

Streambank stability is estimated using a simplified modification of Platts et al. (1983) as stated in "Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams (Bauer and Burton 1993)." The modification allows for measuring streambank stability in a more objective fashion. The lengths of banks on both sides of the stream throughout the entire linear distance of the representative reach are measured and proportioned into four stability classes:

- **Mostly covered and stable (non-erosional)** - streambanks are over 50 percent covered as defined above. Streambanks are stable as defined above. Banks associated with gravel bars having perennial vegetation above the scourline are in this category. *Cumulative Rating 0 - 4 (slight erosion) with a corresponding lateral recession rate of 0.01 - 0.05 feet per year.*
- **Mostly covered and unstable (vulnerable)** - streambanks are over 50 percent covered as defined above. Streambanks are unstable as defined above. Such banks are typical of false banks" observed in meadows where breakdown, slumping, and/or fracture show instability yet vegetative cover is abundant. *Cumulative Rating 5 - 8 (moderate erosion) with a corresponding lateral recession rate of 0.06 - 0.2 feet per year.*
- **Mostly uncovered and stable (vulnerable)** - streambanks are less than 50 percent covered as defined above. Streambanks are stable as defined above. Uncovered, stable banks are typical of streambanks trampled by concentrations of cattle. Such trampling flattens the bank so that slumping and breakdown do not occur even though vegetative cover is significantly reduced or eliminated. *Cumulative Rating 5 - 8 (moderate erosion) with a corresponding lateral recession rate of 0.06 - 0.2 feet per year.*
- **Mostly uncovered and unstable (erosional)** - streambanks are less than 50% Covered as defined above. They are also unstable as defined above. These are bare eroding streambanks and include ALL banks mostly uncovered that are at a steep angle to the water surface. *Cumulative Rating 9+ (severe erosion) with a corresponding lateral recession rate of over 0.5 feet per year*.

Streambanks were inventoried to quanity bank erosion rate and annual average erosion. These data were used to develop a quantitative sediment budget to develop the load allocation. Field methods and bank erosion calculations are presented in Appendix C.

Sediment Monitoring Points

Streambank erosion tends to increase as a function of watershed area (NRCS 1983). Consequently, the lower stream segments of larger watersheds tend to be problem areas. These stream segments are generally alluvial streams commonly classified as response reaches, Rosgen (1996) B and C channel types.

Because it is often unrealistic to survey every stream segment, representative reaches are used and bank erosion rates are extrapolated over a larger stream segment. The length of the reach to be sampled is a function of stream type variability where stream segments with highly variable channel types need a large sample, whereas segments with uniform gradient and consistent geometry need less. The recommended stream length to inventory is at least 3% of the total stream mileage for a statistically representative proportion of a homogenous stream segment.

Stream reaches are subdivided into sites with similar channel and bank characteristics. Breaks between sites are made where channel type and/or dominant bank characteristics change substantially. In a stream with uniform channel geometry, there may be only one site per stream reach, whereas in an area with variable conditions there may be several sites. Subdivision of stream reaches is at the discretion of the field crew leader while the streambank erosion inventory is being performed.

In the Fall Creek watershed, segmentation of the drainage into homogenous reaches was determined by perusal of topographic maps, aerial photos, BURP data (DEQ 1993, 1996, 2001), and during execution of the streambank erosion inventories in October 2002 on Camp and Fall Creeks. Characteristic segments include:

- From its headwaters to the East Fork confluence, Fall Creek is a Rosgen channel type A to B with a V-shaped channel, moderate sinuosity, and a high gradient averaging 2.8%. This reach is impacted by roads and recreation, and possibly by grazing. The riparian area is adjacent to forested coverage.
- From East Fork to the Gibson Creek confluence, Fall Creek is a Rosgen channel type C with a U-shaped channel, high sinuosity, and a low gradient averaging 1%. This reach is impacted by roads, recreation, grazing, and beaver activity. The riparian area is adjacent to rangeland.
- From Gibson Creek to the mouth, Fall Creek is a Rosgen channel type C in a V-shaped channel, moderate sinuosity, and a low gradient averaging less than 1%. This reach is impacted by roads, recreation, grazing, and some mining. The riparian area is adjacent to forested land cover.
- Camp Creek from its headwaters to Forest Route 376 road crossing is a Rosgen channel type C in a V-shaped channel with moderate sinuosity and gradient averaging 4%. This reach is forested and impacted by grazing and roads.
- Camp Creek from the Forest Route 376 road crossing to its confluence with Fall Creek is a Rosgen channel type C in a U-shaped channel with gradient averaging 2%. The sinuosity was naturally moderate, but the stream is currently downcutting until the sinuosity is very low.

Temperature Load Allocation Techniques

Water temperatures in streams affected by nonpoint sources of pollution, particularly grazing, are primarily affected by air temperatures and the amount of direct solar load reaching the stream. Air temperatures are uncontrollable but accounted for somewhat by removing from the analysis of temperature violations those days that exceed the 90th percentile of annual MWMT air temperatures. Solar load is affected by the amount of vegetation and other objects blocking direct sunlight from reaching the stream. The more "effective shade" on the stream, the lower the solar load, and presumably the lower the stream temperature. Effective shade is defined as the amount of solar radiation blocked by shade producing objects in the sun's path as it traverses the sky throughout the day and throughout the year. Canyon walls, stream banks, other kinds of hard structures can provide shade in addition to the traditional view that riparian vegetation provides shade.

The only way to accurately take into account effective shade is to be able to measure the amount of sun blocked by objects as the sun moves across the sky each day throughout the year. The simplest way to do that is to use a solar pathfinder and make a trace of shade producing objects around a stream site on a solar time chart. A solar pathfinder is a table on a tripod holding a solar time chart in the true south direction and covered with a plastic half dome that shows the reflection of objects surrounding it. The solar time chart that is placed on the pathfinder shows the average solar path for each month of the year and amount of time the sun spends at each portion of that path. By visualizing reflected objects in the dome, a tracing is made on the chart of shade producing objects. From the tracing the amount of solar time that the sun is either exposed or blocked by the objects can be determined for each month. Solar time is expressed as a percentage of the entire solar day, thus 100% solar time is the entire length of the sun's path for any given month. Percent solar time can be converted to solar load by multiplying the percent of time the sun is exposed by an average solar load in kWh/m^2/day measured by a flat plat collector facing south with zero tilt determined at the closest United States (US) weather station with such data. In the US the National Renewable Energy Lab (NREL) collected such solar radiation data from 239 sites across the US. In Idaho, these data were collected for Boise and Pocatello.

The solar pathfinder was used to collect solar loadings for Fall Creek in 2003. Tracings were taken in accordance with the method manual provided by the manufacturer (Solar Pathfinder, 2002) at ten systematically placed sites in the middle of the stream from the South Fork Fall Creek to Gibson Creek. At each site the pathfinder was placed in the center of the stream approximately one foot above the water. The pathfinder was oriented to true south by correcting for a 17^o declination. Tracings were made recording all objects providing shade including deciduous vegetation. Thus, only months (May through September) when vegetation are expected to be "leafed out" are viable in the analysis. Data from the ten sites were averaged to provide average estimates of solar time exposed and solar time blocked for each month. The percent solar time exposed was converted to solar load by multiplying it by the solar radiation values for the respective month collected from the Pocatello NREL weather station.

Temperature Monitoring Points

In order to maintain consistency of record, further continuous temperature logger placement should be at the same location near Little Currant Creek as previous data (see Appendix D).

5.2 Load Capacity

The sediment load that can be assimilated by listed streams in the Fall Creek watershed and still meet the State's water quality narrative sediment criteria is unknown. The designated beneficial uses for Camp Creek and Fall Creek are cold water aquatic life and salmonid spawning. These beneficial uses are impacted by sediment loading above the assimilative capacity of the creek. The loading capacity lies somewhere between the current loading level and the sediment loading from natural streambank erosion levels. Cold water aquatic life and salmonid spawning are naturally occurring beneficial uses in Camp Creek and Fall Creek. We therefore assume that cold water aquatic life and salmonid spawning would be fully supported at natural background sediment loading rates. We also assume that natural streambank stability was equal to or greater than 80 percent (Overton et al. 1995).

The goal of this TMDL is to improve the quality of spawning and incubation substrate and rearing habitat for Yellowstone cutthroat trout in Fall Creek. The strategy in this TMDL will be to establish a declining trend in sediment loading, and to regularly monitor the sediment load and beneficial use support. The sediment monitoring target for this TMDL will be the percentage of subsurface fine (less than 0.25 inches diameter) sediment. The percentage of subsurface fine sediment is determined using a modified McNeil (McNeil and Ahnell 1964) sediment sampling technique. See Bunte and Abt (2001) for a comparison of the McNeil procedure with other techniques for sampling depth fines under submerged conditions. This technique is described in Appendix C. One site was sampled for sediment on Fall Creek in October 2002. The site, located on Fall Creek near an unimproved campsite about 100 yards west of Forest Route 077 (Fall Creek Road), had a mean 39% subsurface fine sediment.

The amount of necessary effective shade and, hence, the acceptable solar load for Fall Creek was determined by applying the same level of reduction to solar load as is needed to reduce water temperatures to the 13^{o}C standard. In other words, because a 47% reduction in temperature is needed to reduce the highest water temperture recorded down to 13^{o} (see Table 8), then it was assumed that a 47% reduction in existing solar load was also necessary. This reduced solar load becomes the solar load capacity of the stream.

5.3 Estimates of Existing Pollutant Loads and
5.4 Load Allocation

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR 130.2(I)). Table 11 shows the existing sediment loads in the Fall Creek watershed.

Sediment

Table 11. Existing nonpoint source loads in Fall Creek watershed.

Wasteload Type	Location	Load	Estimation Method
Sediment	Camp Creek	189 tons per mile per year	Streambank Erosion Inventory (NRCS 1983 method described in Appendix C)
Sediment	Fall Creek, East Fork to mouth	65 tons per mile per year	Streambank Erosion Inventory (NRCS 1983 method described in Appendix C)

The sediment load allocation for Fall Creek is developed from streambank erosion inventories conducted by the IDEQ in 2002. The inventories confirm reports listed in the watershed descriptions and show that the primary source of sediment is from streambank erosion. Streambanks within the Fall Creek watershed were found to be:

- 74% erosive in Camp Creek=26% stable
- 36% erosive in Upper Fall Creek=64% stable
- 6% erosive in Lower Fall Creek=94% stable (not included in the TMDL)
- 12% erosive in South Fork Fall Creek=88% stable (not included in the TMDL)

Streambank erosion has been accelerated by degraded riparian conditions resulting from land management. Reduction of stream bank erosion is directly linked to the improvement of riparian vegetation density and structure as well as improved maintenance of road crossings. Increased vegetative cover provides a protective covering of streambanks, reduces lateral recession, traps sediment, and reduces erosive energy of the stream.

The Fall Creek watershed streambank erosion load allocation is based on the assumption that natural background sediment production from streambanks equates to 80% streambank stability as described in Overton et al. (1995), where stable banks are expressed as a percentage of the total estimated bank length. Natural streambank stability potential is generally 80% or greater for Rosgen (1996) A, B, and C channel types in the volcanic and sedimentary geology types that are present in the Fall Creek drainage.

Because the Lower Fall Creek erosion inventory (Gibson Creek to Blacktail Canyon) showed bank stability greater than 80%, only the Upper Fall Creek site was used in the TMDL development. Assuming that the entire listed segment of Fall Creek from the East Fork to the South Fork Fall Creek is as unstable as the Upper Fall Creek site when it truly is more stable in some sections overestimates erosion and provides an additional margin of safety in the TMDL process.

Camp Creek

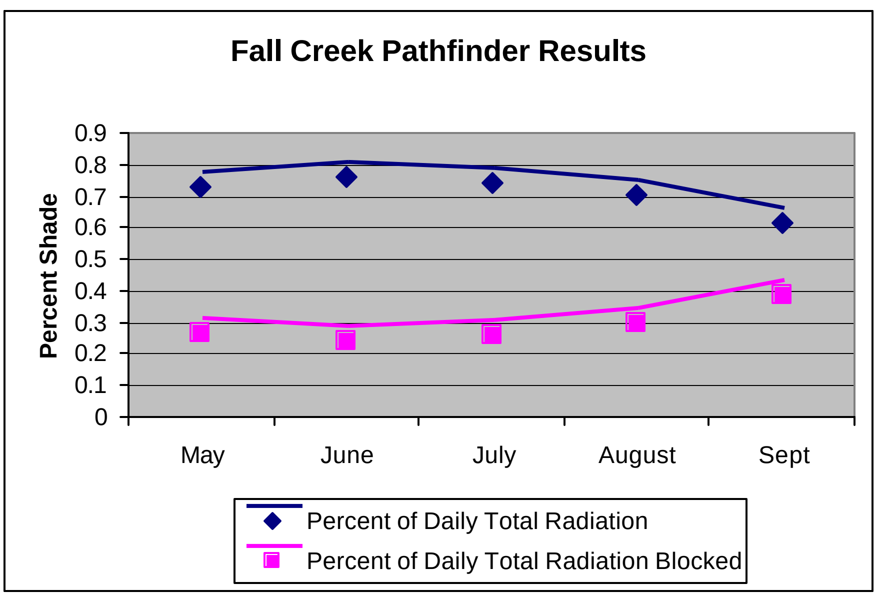
Camp Creek is listed for and unknown pollutant for its entire length from headwaters to confluence with Fall Creek, a total of 4.57 miles. After assessment, it is determined that the listed length is accurate, and that the pollutant is sediment.

Based on the streambank inventory from Camp Creek, the estimated existing sediment load from streambank erosion is 189 tons per mile per year and the existing streambank stability is 26%. The estimated sediment load from streambanks that are 80% stable is 10 tons per mile per year. A sediment load reduction of 179 tons per mile per year is anticipated if 80% or greater streambank stability is achieved. Raw data and the data analysis used to develop these estimates are given in Appendix B.

It is anticipated that by reducing the Camp Creek chronic sediment load by 95% through increased streambank stability, the instream target of 28% subsurface fines will be achieved. If the instream target is attained, it is assumed that the beneficial use of natural spawning by Yellowstone cutthroat trout should eventually be restored to full support. Streambank stability, the percentage of subsurface fines, and age class structure of Yellowstone cutthroat trout must be monitored to determine the effectiveness of land management activities and of this TMDL.

Temperature

Figure 9. The average percent solar time exposed and blocked at Fall Creek during the months of May through September.



The pathfinder results reveal that Fall Creek has an average effective shade of about 30% (percent of daily total radiation blocked or the lower curve in Figure 9). In September, effective shade is a little higher because the sun is lower in the horizon and blocked somewhat more by surrounding hills. Effective shade is lowest in June when the sun is highest in the sky.

The percent of daily total solar radiation (top curve of Figure 9) was converted to solar load by multiplying it times the average solar radiation measured by a flat plate collector in Pocatello. The results are shown in Figure 10. The average solar load for Fall Creek ranges from about 3 kWh/m^2/day during September to over 5 kWh/m^2/day during June and July. The average of all five months is about 4.6 kWh/m^2/day. Figure 10 also shows solar loads calculated from constant effective shade values of 0%, 30%, and 62%. Note that Fall Creek's solar loading is very similar to a constant effective shade of 30%.

Figure 10. Solar radiation load in kWh/m2/day for Fall Creek and three constant effective shade values.

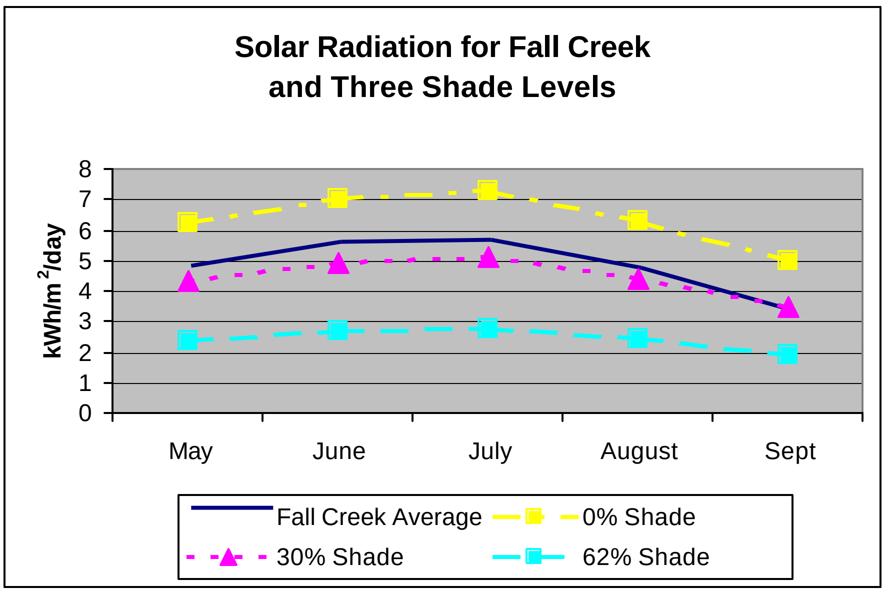


Table 8 in Section 2.3 shows that water temperatures need to be reduced by as much as 47% in order to achieve water quality criteria. For any given surface area and flow, increases in heat load from solar radiation will have a proportional increase in water temperature (see Appendix E, physics of stream temperature, Lower Sucker Creek TMDL, Oregon DEQ). If we assume that a 47% reduction in water temperature can be brought about by a 47% reduction in solar load, then the average Fall Creek solar load needs to decrease from 4.6 kWh/m^2/day to about 2.4 kWh/m^2/day. That reduced solar load is approximately equivalent to the load produced by an effective shade of 62% (see Figure 10). Thus, in order for Fall Creek to experience a load reduction of 47%, the average effective shade on Fall Creek needs to increase from its present state of 30% to about 62%. That can only occur through increased vegetation development, increased canopy cover, and reductions in width/depth ratio. An effective shade of 62% is consistent with data taken on a near pristine riparian area in southern Idaho. DEQ measured an effective shade of 65% on Rock Creek south of Twin Falls where the mature dogwood/river birch riparian community is very thick for rangeland conditions (Shumar, 2003). Rock Creek, although at a lower latitude than Fall Creek, is of similar altitude, size, slope and aspect.

Fall Creek, East Fork to mouth

Fall Creek is listed for an unknown pollutant for from its headwaters to confluence with South Fork Fall Creek, a total of 12.18 stream miles. After assessment, it is determined that the pollutants are sediment and temperature. The listed length should begin at the East Fork confluence with Fall Creek as the upper end of the listed portion and extend to the mouth of Fall Creek, a total of about 11.5 miles.

Based on the streambank inventory from Upper Fall Creek, the estimated existing sediment load from streambank erosion is 65 tons per mile per year and the existing streambank stability is 64%. The estimated sediment load from streambanks that are 80% stable is 11 tons per mile per year for this reach in Fall Creek. A sediment load reduction of 54 tons per mile per year is anticipated if 80% or greater streambank stability is achieved. Raw data and the data analysis used to develop these estimates are given in Appendix B.

It is anticipated that by reducing the Upper Fall Creek chronic sediment load by 83% through increased streambank stability, the instream target of 28% subsurface fines will be achieved. If the instream target is attained, the beneficial use of natural spawning by Yellowstone cutthroat trout should eventually be restored to full support. Streambank stability, the percentage of subsurface fines, and age class structure of Yellowstone cutthroat trout must be monitored to determine the effectiveness of land management activities and of this TMDL.

Fall Creek experiences water temperatures as much as 47% higher than criteria during the spring salmonid spawning period. Because Fall Creek has a current effective shade level of about 30% and an average solar load of 4.6 kWh/m^2/day, a 47% reduction means that Fall Creek needs an effective shade of about 62% to achieve a solar load of 2.4 kWh/m^2/day.

Margin of Safety

In general, a TMDL is the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background (40 CFR 130.2) with a margin of safety (CWA section 303(d)(1)(c)). With no point sources in these two watersheds, the sediment TMDL for Fall and Camp Creeks is the sum of the nonpoint source load allocation (including natural background) and the margin of safety. The margin of safety accounts for uncertainty in the relationship between the sediment load and the quality of the receiving waters. For Fall and Camp Creeks, a margin of safety is provided implicitly through the analytical assumptions made in setting the 80% streambank stability target and in setting the 28% depth fines stream substrate monitoring target. Both of these targets represent conditions found in Idaho wilderness areas. The depth fine sediment target is based on primary literature values and permits an adequate level of survival during egg incubation and alevin swimup to provide for self-sustaining Yellowstone cutthroat trout production.

Additionally, because it is known that not all streambank sections of Camp Creek and Fall Creek are as unstable as the erosion inventories suggest, and because the existing sediment load is based on the assumption that they are unstable at the level determined in the surveys. Therefore, sediment delivery is overestimated as an additional margin of safety.

The margin of safety in the temperature TMDL is implicit in its design. Because the highest data point of the three year data set of stream temperatures is used, a higher level of reduction is invoked than would occur if an average high temperature for the three years had been used.

Seasonal Variation

Seasonal variation in sediment delivery is due to snowmelt runoff and random precipitation events. Variable runoff hydrology must be accounted for in a TMDL. In the Fall and Camp Creek load allocations, we have estimated sediment loads using average annual rates. These rates were derived from physical conditions that developed over a long time period under the influence of peak and base flow conditions. It is difficult to account for seasonal and annual variation within a given season, year, or period of years. However, the seasonal and annual variation is accounted for over the longer time frame under which the observed conditions in Fall and Camp Creeks have developed. Annual erosion and sediment delivery rates are largely dependent on climatic factors where wet water years typically produce the highest sediment loads. The highest rates of erosion typically occur during spring runoff and summer thunderstorms. Since our sediment analysis uses long-term averages, it accounts for streambank recession during high runoff when the soils are saturated.

Seasonal variation in stream temperature also occurs. Because the default spawning period extends to the first of July, a portion of the summer hot period is compared to one of the state’s lowest water temperature standards. Any reductions that occur during this time period as a result of vegetation development along the stream will likely equally affect water temperatures during other times of the year.

Remaining Available Load

Table 12 gives the future loading allocations for the Fall Creek watershed. There are no point sources in the watershed. The nonpoint sources are allocated according to the reaches investigated in the streambank erosion inventory and pathfinder analysis, since the inventoried reaches are homogenous in geomorphology, land use, and impacts to water quality. Since the entire load allocation is given to current nonpoint sources, assuming those sources can achieve the desired reductions, there is no remaining available load for future allocation.

Table 12. Nonpoint source load allocations for Fall Creek Watershed.

Source	Boundaries (and AUs)	Pollutant	Existing Load	Allocation	Reduction
Camp Creek	Headwaters to confluence (ID17040104SK006_02	Sediment	189 tons/mi/yr	10 tons/mi/yr	95%
Fall Creek	East Fork to mouth (ID17040104SK006_04	Temperature	4.6 kWh/m^2/day	2.4 kWh/m^2/day	47%
Fall Creek	From East Fork to mouth (ID17040104SK006_04	Sediment	65 tons/mi/yr	11 tons/mi/yr	83%

5.5 Implementation Strategies

The USFS is the land management agency in the Fall Creek watershed. In the Fall Creek Watershed Analysis of January 2002, the Caribou-Targhee National Forest has recommended improvements to be made to the watershed and rated those improvements in order of importance. The TMDL goals should be attainable after the implementation of all of the recommendations given by the Caribou-Targhee National Forest. DEQ recommends a phased approach for implementation of riparian improvements.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals.

Approach

Streambank stability, percentage of subsurface fines, temperature, and solar pathfinder analysis may be monitored using the same techniques at the same locations as performed by DEQ and USFS staff for comparable results in monitoring implementation success. Alternative techniques and locations used for monitoring must demonstrate improving trends in riparian condition or stream health. These improved trends will ultimatley result in full support of beneficial uses were such attainment is possible.

Responsible Parties

Forest Service staff shall be responsible for installing and monitoring improvements in order to achieve water quality standards. Staff from DEQ shall be responsible for coordinating implementation plans and strategies.

Monitoring Strategy

It is anticipated that by reducing the chronic sediment load through increased streambank stability, the instream target of 28% subsurface fines and the riparian effective shade target will be achieved. If these targets are attained, the beneficial use of cold water aquatic life will eventually be restored to full support. Streambank stability, the percentage of subsurface fines, temperature, effective shade, and macroinvertebrate assemblages must be monitored to determine the effectiveness of land management activities and of this TMDL.

Subsurface fines can affect salmonid production. Chapman (1988) suggested that fine sediment less than 0.03 inches in diameter is most responsible for suffocation and abrasion of salmonid eggs. Tappel and Bjornn (1983) report that sediment less than 0.37 inches in diameter can create a survival barrier preventing salmonid fry emergence from the redd. Hall (1986) found survival (eyed-egg to emergence) of coho, chinook, and chum salmon to be only 7 to 10 percent in gravel mixtures made up of 10 percent fines as compared to 50 to 75 percent survival in gravel mixtures with no fines less than 0.03 inches. Reiser and White (1988) observed little survival of steelhead and chinook salmon eggs beyond 10 to 20 percent fines less than 0.03 inches. These sediment particle size parameters should be considered as part of target monitoring to evaluate any significant shift in subsurface fine particle frequency distribution.

The Fall Creek watershed would be expected to support only resident fish populations, since the 60-foot waterfall at the mouth presents a barrier to migration of anadromous fish. In streams supporting only resident salmonid fish species, 28.7% fine sediment of particles less than 0.25 inches (6.35 mm) in diameter sampled to a depth of four inches is the standard target for the survival of spawning salmonids (USFS-Salmon National Forest 1988). The DEQ target for 28% subsurface fines applies to appropriate habitat in pool tail-outs, where fish spawn. According to general guidance (USFS-Salmon National Forest 1988), in volcanic and sedimentary parent materials like the Fall Creek watershed geology, streams will display the following percentages of subsurface fine sediment:

- Good condition = <25%;
- Fair condition = 25-30%; and
- Poor condition = >30%.

However, the proportion of depth fines in a stream is a function of the channel geometry more than the supply of parent material in the watershed. As a stream loses its ability to transport fine sediment due to channel widening or downcutting, fine sediment at four inches depth increases (Rosgen 1996).

Measurement of subsurface fines at a depth of at least four inches is more indicative of salmonid fry emergence and survival than measurement of surface fines. Surface fine sediment is easily swept away by altered streamflows or the fish themselves while building redds for spawning. Surface fine sediment may be useful in trend analysis, but there is not a clear relationship between surface fine sediments and subsurface fine sediments which impact salmonid fry emergence and survival (Nelson 1997).

The subsurface fine sediment target for Fall Creek is 28% or less subsurface fine sediment, not including sediment particles larger than 2.5 inches, in areas suitable for salmonid spawning. Fine sediment is defined as particles 6.3 mm (0.25 inches) and less. It is anticipated that the amount of habitat suitable for salmonid spawning will increase after implementation of management practices identified to reduce subsurface fine sediment. Subsurface fine sediment and salmonid age class structure will be monitored in the future. If the percentage of subsurface fine sediment is not decreasing, additional management practices will be implemented to trend toward the target.

The percentage of subsurface fine sediment will be determined using a modified McNeil sediment sampling procedure (McNeil and Ahnell 1964). The McNeil technique is described in Appendix C.

5.6 Conclusions

The Fall Creek watershed supports many valuable resources, including wildlife habitat, travertive hot springs, an aesthetically-valuable 60-foot waterfall and native Yellowstone cutthroat trout fisheries. When the current excessive sedimentation in the upper watershed is reduced and riparian shade is increased, the Fall Creek watershed may rebound to be a unique and correctly-functioning surface water system, fully supporting its beneficial uses according to water quality standards.

References Cited

40 CFR 130. Water quality planning and management.

Abramovich, R., M. Molnau, and K. Craine. 1998. Climates of Idaho. University of Idaho College of Agriculture: Moscow, ID. 216 pp.

Alt, D., and D.W. Hyndman. 1989. Roadside Geology of Idaho. Mountain Press Publishing Co.: Missoula, MT. 393 pp.

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. Idaho Water Resources Research Institute: Moscow, ID. 207 pp.

Baxter, G.T. and M.D. Stone. 1995. Fishes of Wyoming, Wyoming Game and Fish Department: Cheyenne, WY.

Bunte, K. and S.R. Abt. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analysis in sediment transport, hydraulics, and streambed monitoring. USFS Rocky Mountain Research Station. General Technical Report RMRS-GTR-74: Boise, ID. 445 pp.

Cannon, M. R. 1979. Conceptual models of interactions of mining and water resource systems in the southeastern Idaho phosphate field. University of Idaho College of Mines: Moscow, ID. 106 pp.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society. 177(1):1-20.

Clark, W.H. 2000. Palisades (HUC17040104) Bonneville, Madison, and Teton Counties, Idaho subbasin assessment biotic integrity (macroinvertebrates). Published in Appendix B of the Palisades subbasin assessment and total maximum daily load allocations. Idaho Department of Environmental Quality: Boise, ID. 15 pp.

Department of the Navy. 1982. Soil mechanics design manual 7.1. NAVFAC DM-7.1. Naval Facilities Engineering Command: Alexandria, VA. 380 pp.

DEQ. 1993. Beneficial use reconnaissance survey data. Idaho Falls Regional Office. Idaho Falls, ID.

DEQ. 1996. Beneficial use reconnaissance survey data. Idaho Falls Regional Office. Idaho Falls, ID.

DEQ. 1999. 1998 303(d) list. Idaho Division of Environmental Quality. Idaho Department of Health and Welfare. Boise, ID. 484 pp.

DEQ. 2001. Beneficial use reconnaissance survey data. Idaho Falls Regional Office. Idaho Falls, ID.

DEQ. 2002. Streambank erosion inventory and pollutant source investigations. State Office of Technical Services. Boise, ID.

Drewes, B.R. 1991. Antelope-Pine Creek area - Bonneville, Jefferson, Madison, and Teton Counties, Idaho 1988-1989. Water quality status report no. 99. Idaho Department of Health and Welfare, Division of Environmental Quality, Pocatello Field Office: Pocatello, ID. 162. pp.

East Side Soil and Water Conservation District. 1989. Agricultural pollution abatement plan for the Antelope-Pine Creek watershed South Fork of the Snake River: final planning report. East Side Soil and Water Conservation District: Idaho Falls, ID. 106 pp.

East Side Soil and Water Conservation District. 1991. Plan of operations: Antelope Creek project Idaho state agricultural water quality program. East Side Soil and Water Conservation District: Idaho Falls, ID. 31 pp.

EPA. 2000. 1998 Idaho 303(d) list: waters proposed to be added. US Environmental Protection Agency, Region 10: Seattle, WA. 6 pp.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, D.T. Mosier. 2002. The Idaho Department of Environmental Quality waterbody assessment guidance, 2nd ed. Idaho Department of Environmental Quality: Boise, ID. 114 pp.

Idaho Code § 39.3611. Development and implementation of total maximum daily load or equivalent processes.

Idaho Data Center, community profiles. (Web Page). Idaho Department of Commerce. August 28, 2002. URL: <http://www.idoc.state.id.us/idcomm/cntypro.html> and <http://www.idoc.state.id.us/idcomm/profiles/pdfs/Bonneville.pdf>.

Idaho Water Resource Board. 1996. Comprehensive state water plan: South Fork Snake River basin. Idaho Water Resource Board: Boise, ID. 143 pp.

IDAPA 58.01.02. Idaho water quality standards and wastewater treatment requirements.

IDFG. 1996. Fisheries management plan 1996-2000. Idaho Department of Fish and Game: Boise, ID. 272 pp.

IDWR. (Web Page). Drillers' Report Search. August 28, 2002. URL:< http://www.idwr. state.id.us/info/water/drilling/Search.htm>.

Jobin, D. A. and M. L. Schroeder. Geology of the Conant Valley Quadrangle Bonneville County, Idaho. Department of the Interior. United States Geological Survey. Mineral Investigations Field Studies Map MF-277. 1 map.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History: Raleigh, NC.

Maley, T. 1987. Exploring Idaho Geology. Mineral Land Publications: Boise, ID. 232 pp.

Maret, T.R. 1997. Characteristics of fish assemblages and related environmental variables for streams of the upper Snake River basin, Idaho and western Wyoming, 1993-95. National Water Quality Assessment Program. Water-resources investigations report 97-4087. US Geological Survey: Boise, ID. 50 pp.

May, B.E. 1996. Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri*. *In* D.A. Duff (technical editor). Conservation assessment for inland cutthroat trout - distribution, status and habitat management implications. US Forest Service, Intermountain Region: Ogden, UT. 131 pp.

McNeil, W.J. and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. US Fish and Wildlife Service, Special Scientific Report-Fisheries No. 469.

Merigliano, M.F. 1996. Ecology and management of the South Fork Snake River cottonwood forest. Technical Bulletin 96-9. Idaho Bureau of Land Management: Idaho Falls, ID 103 pp.

Moore, V.K. and D.J. Schill. 1984. River and stream investigations - fish distribution and abundance in the South Fork Snake River. Idaho Department of Fish and Game, Upper Snake Region: Idaho Falls, ID. 133 pp.

Moseley, R. 1997. Ute ladies' tresses (*Spiranthes diluvialis*) inventory: Snake River corridor and other selected areas. Conservation Data Center, Idaho Department of Fish and Game: Boise, ID. 24 pp.

Natural Resources Conservation Service. 1983. Erosion and sediment yield. *In*: proceedings from the channel evaluation workshop. Ventura, CA. 54 pp.

Nelson, R.L., L.J. Wagoner, D.C. Burns, D.D. Newberry, and J. Lund. 1997. Deposition of fine sediment in selected streams on the Payette and Boise National Forests, Idaho; report of sediment trends and monitoring effects, 1977-1996. Payette and Boise National Forests, McCall and Boise, ID.

Omernik, J.M. and A.L. Gallant. 1986. Ecoregions of the Pacific Northwest. US EPA, Environmental Research Laboratory. EPA/600/3-86/033. Corvallis, OR.

Overton, C.K., J.D. McIntyre, R. Armstrong, S.L. Whitwell, and K.A. Duncan. 1995. User's guide to fish habitat: descriptions that represent natural conditions in the Salmon

River Basin, Idaho. USFS Intermountain Research Service. General Technical Report INT-GTR-322. 142 pp.

Reiser, D.W. and R.G. White. 1988. Effects of two sediment size-classes on survival of steelhead and Chinook salmon eggs. North American Journal of Fisheries Management. 8:432-437.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology: Pagosa Springs, CO. 355 pp.

Rupert, M. 1994. Analysis of data on nutrients and organic compounds in ground water in the upper Snake River basin, Idaho and western Wyoming, 1980-91. Water-Resources Investigations Report 94-4135. US Geological Survey: Boise, ID. 46 pp.

Shumar, M. 2003. Feasibility of canopy coverage estimation for temperature TMDL targets in non-forested streams. Idaho Department of Environmental Quality. Boise, ID. 17pp.

Simpson, J.C. and R.L. Wallace. 1982. Fishes of Idaho. University of Idaho Press: Moscow, ID.

Soil Conservation Service. 1981. Soil survey of Bonneville County area, Idaho. US Soil Conservation Service: Boise, ID. 147 pp.

Solar Pathfinder. 2002. Instruction Manual for the Solar Pathfinder. Copyright 2002 Solar Pathfinder, Linden, TN.

Tappel, P.D. and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management. 3:123-125.

USFS Caribou National Forest. 1999. Analysis of the management situation. US Forest Service: Pocatello, ID. 165 pp.

USFS Caribou-Targhee National Forest. 2002. Fall Creek Watershed Analysis. US Forest Service, Caribou-Targhee National Forest, Palisades Ranger District: Idaho Falls, ID. 252 pp.

USFS Salmon National Forest. 1988. Land and Resource Management Plan for the Salmon National Forest.

USFS Targhee National Forest. 1997. Revised forest plan. Palisades Ranger District: St. Anthony, ID. 388 pp.

USFS Targhee National Forest. 1999. 1999 cutthroat trout distribution survey report. Unpublished data. Palisades Ranger District: Anthony, ID.

USFS Targhee National Forest. 2000. 2000 cutthroat trout distribution survey report. Unpublished data. Palisades Ranger District: St. Anthony, ID. 48 pp.

USGS. 1987. Hydrologic unit maps. Water supply paper 2294. United States Geological Survey: Denver, CO. 63 pp.

USGS. 2002. Surface water data for USA: monthly streamflow statistics (Web Page). August 28, 2002. URL: <http://waterdata.usgs.gov/nwis/monthly>.

Western Regional Climate Center (Web Page). August 26, 2002. URL: <http://www. wrcc.dri.edu/ summary/climsmid.html>.

Zaroban, D.W., M.P. Mulvey, T.R. Maret, and R.M. Hughes. 1999. Classification of Species Attributes for Pacific Northwest Freshwater Fishes. Northwest Science, Vol. 73, No. 2. Northwest Scientific Association. 13 pp.

Zaroban, D.W. and D. Sharp. 2001. Palisades subbasin assessment and total maximum daily load allocations. Idaho Department of Environmental Quality: Boise, ID. 128 pp.

GIS Coverages:

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IDFG and FWS. 1978. Stream evaluation map - State of Idaho. 1:500,000 scale. Boise, ID.

IDWR. 1994-1997. Fifth field HUC statistics calculated from 1:24,000 scale data.

IDWR. 1994-1996. Stream mileage calculated from 1:100,000 scale data.

Idaho Water Resource Board. 1990. Land use calculated from 1:500,000 scale data.

Idaho Water Resource Board. 1992. Land ownership calculated from 1:100,000 scale data with contributions from US BLM.

USGS. 1992. Data derived from 1:500,000 scale data calculations.

USGS. 1996. Data calculated from 1:100,000 scale data stream segment hydrography and 1:250,000 scale 4th field HUCs.

Glossary

305(b)
Refers to section 305 subsection "b" of the Clean Water Act. 305(b) generally describes a report of each state's water quality, and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)
Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of waterbodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Alevin
A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a waterbody, living off stored yolk.

Antidegradation
Refers to the U.S. Environmental Protection Agency's interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water's uses (IDAPA 58.01.02.003.56).

Aquatic
Occurring, growing, or living in water.

Aquifer
An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.

Assemblage (aquatic)
An association of interacting populations of organisms in a given waterbody; for example, a fish assemblage, or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).

Assimilative Capacity	The ability to process or dissipate pollutants without ill effect to beneficial uses.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic biota, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.
Beneficial Use Reconnaissance Program (BURP)	A program for conducting systematic biological and physical habitat surveys of waterbodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers
Benthic	Pertaining to or living on or in the bottom sediments of a waterbody
Biological Integrity	1) The condition of an aquatic community inhabiting unimpaired waterbodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).
Biota	The animal and plant life of a given region.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation’s water resources.
Community	A group of interacting organisms living together in a given place.
Conductivity	The ability of an aqueous solution to carry electric current, expressed in micro (µ) mhos/cm at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.

Criteria In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. EPA develops criteria guidance; states establish criteria.

Cubic Feet per Second A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

Depth Fines Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 mm depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 cm).

Designated Uses Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.

Discharge The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen (DO) The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

Disturbance Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.

Ecosystem The interacting system of a biological community and its non-living (abiotic) environmental surroundings.

Environment The complete range of external conditions, physical and biological, that affect a particular organism or community.

Erosion The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

Existing Beneficial Use or Existing Use	A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).
Extrapolation	Estimation of unknown values by extending or projecting from known values.
Flow	See Discharge.
Fully Supporting	In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).
Fully Supporting Cold Water	Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions (EPA 1997).
Geographical Information Systems (GIS)	A georeferenced database.
Gradient	The slope of the land, water, or streambed surface.
Grazing	**Activity** that has a potential impact on surface water quality. As differing from rangeland, which is a **land use** with human management issues.
Groundwater	Water found beneath the soil surface saturating the layer in which it is located. Most groundwater originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.

Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.
Hydrologic Unit Code (HUC)	The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.
Hydrology	The science dealing with the properties, distribution, and circulation of water.
Instantaneous	A condition or measurement at a moment (instant) in time.
Intergravel Dissolved Oxygen	The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.
Load Allocation (LA)	A portion of a waterbody's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Loading Capacity (LC)	A determination of how much pollutant a waterbody can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.

Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Margin of Safety (MOS)	An implicit or explicit portion of a waterbody's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving waterbody. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mass Wasting	A general term for the down slope movement of soil and rock material under the direct influence of gravity.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Metric	1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.
Monitoring	A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a waterbody.
Mouth	The location where flowing water enters into a larger waterbody.
National Pollution Discharge Elimination System (NPDES)	A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.
Natural Condition	A condition indistinguishable from that without human-caused disruptions.

Nonpoint Source	A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.
Not Fully Supporting	Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).
Not Fully Supporting Cold Water	At least one biological assemblage has been significantly modified beyond the natural range of its reference condition (EPA 1997).
Parameter	A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.
Perennial Stream	A stream that flows year-around in most years.
PH	The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.
Phased TMDL	A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a waterbody. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.
Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.

Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution	A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.
Protocol	A series of formal steps for conducting a test or survey.
Qualitative	Descriptive of kind, type, or direction.
Quantitative	Descriptive of size, magnitude, or degree.
Rangeland	**Land use** with human management issues. As differing from grazing, an **activity** that has a potential impact on surface water quality.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.
Redds	The spawning ground or nest of various fishes
Reference	A physical or chemical quantity whose value is known, and thus is used to calibrate or standardize instruments.
Resident	A term that describes fish that do not migrate.
Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.
Riparian	Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a waterbody.

Riprap A foundation or sustaining wall of stones or chunks of concrete thrown together without order (as in deep water); *also* **:** a layer of this or similar material on an embankment slope to prevent erosion. The usage of the term riprap implies an engineered rather than a natural condition.

Rosgen Classification A system of geomorphic characterization for surface water flows. The general descriptions of the stream types are rated according to entrenchment ratio, width/depth ratio, sinosity, gradient, and landform features.

Runoff The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.

Sediments Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.

Spawning The production of eggs by an aquatic animal.

Species 1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.

Stream A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.

Stream Order Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.

Subbasin A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} field hydrologic units (also see Hydrologic Unit).

Subwatershed	A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.
Surface Fines	Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 mm depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.
Surface Runoff	Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants to rivers, streams, and lakes. Surface runoff is also called overland flow.
Surface Water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.
Tail-out	The region directly downstream of a pool. Generally cobble-sized substrate and well-oxygenated riffle habitat for best spawning ground.
Taxon	Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).
Total Maximum Daily Load (TMDL)	A TMDL is a waterbody's loading capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. TMDL = Loading Capacity = Load Allocation + Wasteload Allocation + Margin of Safety. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several waterbodies and/or pollutants within a given watershed.
Total Dissolved Solids	Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)	The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Greenborg, Clescevi, and Eaton 1995) call for using a filter of 2.0 micron or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.
Toxic Pollutants	Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.
Tributary	A stream feeding into a larger stream or lake.
Turbidity	A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.
Wasteload Allocation (WLA)	The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a waterbody.
Waterbody	A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.
Water Column	Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.
Water Pollution	Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.
Water Quality	A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria	Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.
Water Quality Limited	A label that describes waterbodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.
Water Quality Standards	State-adopted and EPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses.
Watershed	1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a waterbody.
Young of the Year	Young fish born the year captured, evidence of spawning activity.